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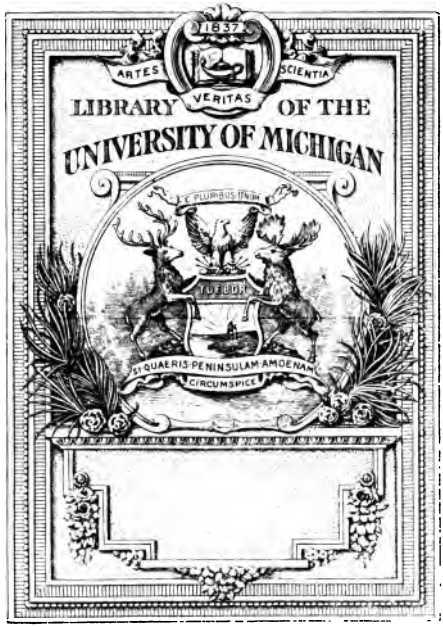
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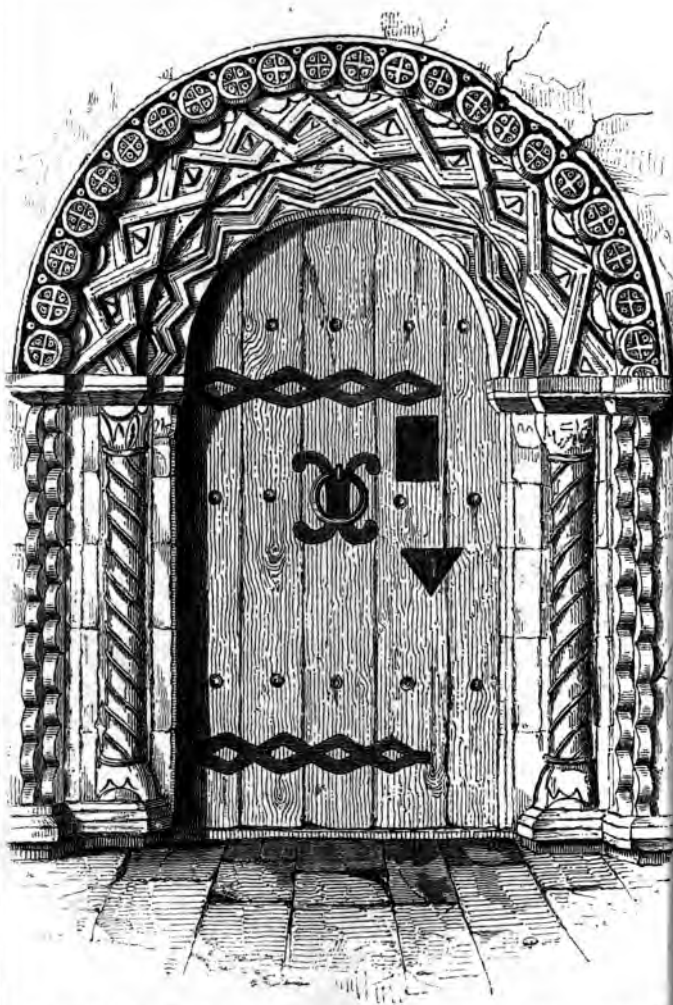

The doorway on the south side of Great Redisham Church is of a date considerably anterior to the first Edward's reign: it *affords a good example of the rude Norman architecture so prevalent in the Suffolk churches.*

4746

RUDIMENTARY

DICTIONARY OF TERMS

USED IN

ARCHITECTURE, CIVIL,
ARCHITECTURE, NAVAL,
BUILDING AND CONSTRUCTION,
EARLY AND ECCLESIASTICAL ART,
ENGINEERING, CIVIL,
ENGINEERING, MECHANICAL,
FINE ART,
MINING, SURVEYING, ETC.

LIBRARY OF THE UNIVERSITY OF MICHIGAN

TO WHICH ARE ADDED

EXPLANATORY OBSERVATIONS

ON

VARIOUS SUBJECTS CONNECTED WITH PRACTICAL ART AND SCIENCE.

BY JOHN WEALE,

AUTHOR OF

Treatise entitled 'Divers Works of Early Masters in Christian Decoration, with Examples of Ecclesiastical Ornament, Ancient Painted and Stained Glass,' in two folio volumes;

AND EDITOR OF

'Examples of Railway Making;'
'Papers on Architecture,' in four volumes quarto; and
'Papers on Engineering,' in six volumes quarto.

London:

JOHN WEALE, 59, HIGH HOLBORN.

1849–50.

HUGHES AND ROBINSON, PRINTERS,
KING'S HEAD COURT, GOUGH SQUARE.

PREFACE.

It was intended that the contents of this work should be comprised within the space of about one hundred and fifty pages, and thus form a single volume of the series of 'Rudimentary Treatises;' but in the course of its compilation it soon became apparent that such confined limits were wholly inadequate to the admission of explanations of terms, which, although not immediately connected with the subjects mentioned in the title-page, were yet deemed essential to their further amplification: its utility as a book of reference will therefore, it is hoped, be found commensurate with its necessarily increased extent.

Since the publication, in 1819, of Mr. Peter Nicholson's elaborate 'Architectural Dictionary,' in two quarto volumes, changes of vast import have occurred: the field of practical science has been widely extended, and proportionately occupied by a new generation of professional men and students; important advances have been made in the arts of design and construction; and the extended application of steam as a motive power has not only produced an extraordinary development of the means of internal communication, but surmounted those impediments which considerations of space and time formerly presented to the pursuits of men in quest of business or pleasure,—thus influencing, to a great extent, the various operations by which the wants and luxuries of civilized life are supplied.

In a ratio proportionate to the rapid extension of what

may be strictly termed practical knowledge has the study of the more pleasurable sciences also progressed: archæology, geology, philosophy, &c., have exercised a powerful and captivating influence, which has gradually led to the incorporation of societies or associations devoted to the cultivation and advancement of the several branches of human knowledge; and hence has arisen an extensive class of non-professional men, who, however duly acquainted with scientific principles, may yet be anxious to possess any easily available means of becoming familiar with the nomenclature and the technical language necessarily employed in a series of rudimentary treatises on the practical arts and sciences.

Within the period already adverted to, much professional taste and skill has been displayed in the erection of public buildings, in the construction of engineering works of vast magnitude and importance, and in the invention of the improved machinery employed in the arts and manufactures of the country. These and similar causes have combined greatly to augment the ranks of a meritorious and useful class of men, among whom, more especially, new wants may be said to have been created, — a class which comprises no inconsiderable number of ingenious operative engineers and matured artisans; and to such this work may become interesting and useful, however insufficient it may prove to those already advanced in their professional pursuits.

Should, however, the paucity of information contained in the following pages induce others more competent to the task, and who have sufficient leisure for the purpose, to devote their talents and time to the production of a more comprehensive and more valuable compilation, some share of useful information will at least have been contributed to the means of supplying the wants of an improving age.

The slender efforts here placed before the reader were

accomplished, by the aid of the lamp, after the hours usually devoted to the labours of business, and they are now, with the most humble pretensions, submitted to public approval. It has been well observed, that 'the language of truth is simple:' no attempt has here been made to trace the derivations of the scientific or technical terms which have been adopted: they are given and explained as generally written and understood at the present period, and care has been taken to avoid surreptitious or unauthorized versions, with the view of guiding the student and the operative workman in the onward path of knowledge.

Some analogous explanations and references may probably appear, at a first glance, as superfluous, and to detract from the merits of the work; but when it is considered how numerous and varied, in the present age, are the ramifications into which the employment of those engaged in the building and constructive arts has been extended, and how earnestly the searchers after technical terms and meanings must desire the acquisition of a knowledge of what may not inaptly be designated as a correct disposition of fine art, any unfavourable impression of this nature, hastily formed, will probably be removed upon mature reflection.

The collation made from Dugdale's 'Monasticon,' of the abbeys, alien priories, collegiate churches, monasteries, &c., with their several orders, dates of foundation, and localities, may perhaps be looked on with indifference by the mechanical engineer, as embracing subjects of little or no importance; but viewed archæologically, by the architect, the historian, or the antiquary, a reference to researches into the early architecture of his country must ever command a paramount degree of interest. Similarly, with the latter class, objections may be raised with regard to subjects merely mechanical; *and it is therefore earnestly to* be desired that each may be

disposed to indulge the predilections of the other as to their more favoured pursuits.

In referring to the series of 'Rudimentary Scientific Works' to which this 'Dictionary of Terms' will, it is presumed, be deemed an appropriate *Companion*, it is proper to mention that the first suggestion as to their publication emanated from Lieutenant-Colonel Reid, of the Corps of Royal Engineers, who, during his residence at Barbadoes as Her Majesty's representative, kindly forwarded to the Publisher, with a recommendation that it should be printed for general circulation, a copy of Professor Fownes's 'Rudimentary Chemistry.' This elementary treatise, the first of the series, and to which the recommendation of the late Governor of Barbadoes was limited, had been printed at his own expense, for the laudable and special purpose of adding to the numerous educational and scientific works which he had already distributed among different classes in the West India colonies.

To Lieut.-Colonel Portlock, R. E.,—to the Commissioners of Northern Lighthouses, and to others who have liberally contributed their assistance in the production of the succeeding treatises, the Publisher thus acknowledges his obligations; and as the series has been extended to thirty volumes, the public have now the means of forming a due estimate of their efficacy and utility, and of the discretion exercised in the selection of subjects.

J. W.

59, High Holborn,
November 1, 1849.

LIBRARY OF THE UNIVERSITY OF MICHIGAN

LIST OF THE WORKS WHICH HAVE BEEN CONSULTED IN THE COMPILATION OF THIS DICTIONARY.

Adcock's Rules and Data for the Steam Engine, &c. 12mo. 1839.
Aide-Mémoire to the Military Sciences, Parts I. II. III. 1845–8.
Britton's Architectural Dictionary. 4to. 1838.
Brown's Principles of Perspective. 4to. 1835.
Buchanan's Technological Dictionary. 12mo. 1849.
——— Practical Essays on Mill-work and on Machinery and Tools. 2 vols. 8vo.: edited by George Rennie, 1841.
Builder's (the) Dictionary. 2 vols. 4to. 1788.
Bury's Styles of Architecture. 12mo. 1849.
Calmet's Dictionary of the Bible. 8vo. 1848.
Campbell's Text-Book of Inorganic Chemistry. 12mo. 1849.
Castell's Villas of the Ancients. fol. 1728.
Clegg's Essay on the Architecture of Machinery. 4to. 1842.
——— Manufacture and Distribution of Coal Gas. 4to. 1840.
Dana's Seaman's Vade Mecum. 12mo. 1849.
Dempsey's Practical Railway Engineer. 4to. 1847.
Dictionary of Painters, Sculptors, and Engravers. 8vo. 1810.
Dodd's (Ralph) Observations on Water. 18mo. 1805.
Dugdale's Monasticon Anglicanum. 8 vols. folio: now in course of republication in guinea parts.
Ensamples of Railway Making. 8vo. 1843.
Ewbank's Hydraulics and Machinery. 8vo. New York, 1849.
Fergusson's Rock-Cut Temples of India: plates folio, text 8vo. 1845.
Field's Chromatography. 8vo. 1841.
Gardner's Railway Mensuration: imperial 8vo. 1848.
Glossary of Architecture. 2 vols. Oxford, Parker. 1845.
Greir's Mechanical Dictionary. 12mo. 1847.
Gregory's Mathematics for Practical Men, by Henry Law: large 8vo. 1848.

Gwilt's (Joseph) Encyclopædia of Architecture. 8vo. 1847.
——————— edition of Sir William Chambers's Civil Architecture. 2 vols. imperial 8vo. 1824.
——————— Notitia Architectonica Italiano. 8vo. 1818.
Hamilton on Terms used in the Arts and Sciences. 12mo. 1825.
Hann's Theoretical and Practical Mechanics. 8vo. 1849.
Hann's, &c. Theory and Practice of Bridges. 4 vols. in 3: large 8vo. 1843.
Holzapffel's Turnery and Mechanical Manipulation. 2 vols. 8vo. 1846–7.
Homersham on Water Supply to Manchester and the adjacent Towns. 8vo. 1849.
Hunt's Tudor Architecture. 4to. 1830.
Hutton's Mathematical and Philosophical Dictionary. 2 vols. 4to. 1815.
Jamieson's (Dr.) Dictionary of Mechanical Science. 4to. 1827.
——————— Mechanics for Practical Men. 8vo. 1830.
Leeds's Preface to Lamb's Studies: imperial 4to.
Leeds's Rudimentary Treatise on the Orders of Architecture. 12mo. 1849.
Meason's Architecture of the Great Painters of Italy. 4to. 1828.
Meteorological Society's Transactions, vol. i. large 8vo. 1839.
National Encyclopædia, now in course of publication by Mr. Charles Knight, in monthly parts.
Nicholson's Architectural Dictionary. 2 vols. 4to. 1819.
———— Mechanical Exercises. 8vo. 1819.
Normand's Parallel of the Orders of Architecture, by Pugin: folio. 1829.
Palladio's Architecture, with Notes by Inigo Jones. 2 vols. folio. 1742.
Pambour's Practical Treatise on Locomotive Engines. 8vo. 1840.
Papers connected with the Duties of the Corps of Royal Engineers. 10 vols. 4to. 1835–1849.
Pole on the Cornish Pumping Engine. 1 vol. 4to. folio plates. 1844.
Pryce's Treatise on Mines and Minerals. folio. 1773.
Pugin's True Principles of Pointed or Christian Architecture. 4to. 1841.
——— Apology for the Revival of Christian Architecture in England. 4to. 1843.
Reid (Lieut.-Col.) on the Law of Storms: large 8vo. 1842.
Repton's Theory and Practice of Landscape Architecture: large 4to. 1805.
Rich's Companion to the Greek Lexicon and Latin Dictionary. 8vo. 1849.
Smith's Classical Dictionary: large 8vo. 1849.
Stalkartt's Naval Architecture. 2 vols. folio. 1803.
Stephenson's (Robert) Report on the Atmospheric Railway System. 4to. 1844.
Stuart's Antiquities of Athens. vols. ii. & iii. folio: last edition. 1825.
Thorman's Taunus Railway. 4to. 1846.
Tomlinson's Rudimentary Natural Philosophy. 12mo. 1848.

Transactions of the Institution of Civil Engineers. 3 vols. 4to. 1835–40.
Tredgold on the Steam Engine. 2 vols. 4to. 1838–1849.
Tredgold on the Strength of Cast Iron. 8vo. 1842.
Tredgold's Elementary Principles of Carpentry. 4to. 1840.
Vicat on Cements, by Capt. Smith. 8vo. 1837.
Vitruvius's Civil Architecture, by Wilkins: imperial 4to. 1812.
Wathen's Arts, Antiquities, and Chronology of Ancient Egypt: large 8vo. 1843.
Watson's Account of Mines. 8vo. 1843.
Wightwick's Hints to Young Architects. 8vo. 1846.
Willis's (Professor) Architectural Nomenclature. 4to. Cambridge.
Wood's Letters of an Architect from France, Italy, and Greece. 2 vols. 4to. 1828.

NOTICE.

The two Parts of the work now published, it will be perceived, extend only to the letter *M*: the remaining portion is now in the press, and will probably be ready for publication by the end of the present year; but as various works have necessarily to be consulted for correct definitions and explanations, the time required for its completion will not, it is presumed, be deemed unreasonable.

*** For each Part, comprising six sheets, or 144 pages, 1*s.* is charged; or for the two Parts, bound together, and containing 12 sheets, or 288 pages, 2*s.*

DICTIONARY OF TERMS

USED

IN ARCHITECTURE, BUILDING, ENGINEERING,

NAVAL ARCHITECTURE, ARCHÆOLOGY, &c.

AARON'S-ROD, an ornamental figure representing a rod with a serpent entwined about it; improperly called the *caduceus* of Mercury

Abaciscus, small tesseræ or square stones for tesselated pavement

Abacot, the cap of state, a double crown formerly worn by the sovereigns of England

Abaculus, a small table or desk

Abacus, a small tile or covering member of a capital, varying in the several orders: in Grecian Doric, square, without chamfer or moulding; in Roman Doric it has an ogee or fillet round the upper edges; in the Tuscan, a plain fillet and a cavetto under it; in Grecian Ionic it is thinner, with ovolo only; in Roman Ionic, an ogee and ovolo, and fillet above; in the Saxon and Norman styles, and in early English, it varies in form and substance,—flat, chamfered, and hollow, circular and octagonal, with mouldings, latterly decorated

Abacus major, a large trough to wash in

Abaft, towards the stern of a ship

Abaised, in heraldry, a term applied to the wings of eagles when the tips are depressed below the centre of the shield

Abaiser, burnt ivory, or ivory black

Abamurus, a buttress or second wall, added to strengthen another

Abatement, in heraldry, a figure in a coat of arms expressing stain or dishonour

Abat-jour, a skylight, or aperture for the admission of light

Abattoir, a building appropriated to the slaughtering of cattle

Abat-vent, the sloping roof of a tower; a pent-house

Abat-voix, the sounding board over a pulpit or rostrum

Abbey, a building annexed to or adjacent to a convent or monastery, for the residence of the abbot or abbess, and the whole combining a series of buildings for the accommodation of a fraternity under ecclesiastical government

Abbeys in Great Britain and Ireland, alphabetically arranged, with their respective orders, the dates of their foundation, and their several localities:

NAME.	ORDER.	DATE.	COUNTY.
Abbotsbury . . .	Benedictine	circa 1026	Dorsetshire
Aberbrothic . . .	Tyrone	1178	Forfarshire
Abingdon	*Benedictine*	ante 955	Berkshire
Alcester	*Do.*	1140	Warwickshire
Alnwick	*Premonstrant*	1147	Northumberland

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Appleby	White Monks	1281	Westmoreland
Athelney	Benedictine	circa 888	Somersetshire
Austin	Augustine	1005	Do.
Balmerinoch	Cistercian	1229	Fifeshire
Ballintobber	Augustine	1216	Mayo
Bardney	Benedictine	temp. W. Con.	Lincolnshire
Bardsey Island	Black Friars	1276	Caernarvonshire
Barling	Premonstrant	1154	Lincolnshire
Basingwork	Cistercian	1159	Flintshire
Battle	Benedictine	1067	Sussex
Bayham	Premonstrant	1200	Do.
Beauchief	Do.	1183	Derbyshire
Beaulieu	Cistercian	1204	Hampshire
Bermondsey	Do.	1082	Surrey
Bileigh	Premonstrant	1180	Essex
Bindon	Cistercian	1172	Dorsetshire
Bisham	Augustine	1338	Berkshire
Bittlesden	Cistercian	1147	Buckinghamshire
Blanchland	Premonstrant	1165	Northumberland
Blanchland	Cistercian	1143	Carmarthenshire
Bordesley	Do.	1138	Worcestershire
Bourn	Augustine	1138	Lincolnshire
Boxley	Cistercian	1146	Kent
Bruerne	Do.	1147	Oxfordshire
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Buckland	Do.	1278	Do.
Builderwas	Do.	1135	Shropshire
Burnham	Augustine	1255	Buckinghamshire
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Byland	Cistercian	1177	Yorkshire
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Calder	Do.	1134	Cumberland
Calke	Augustine	1161	Derbyshire
Cambus Kenneth	Do.	1147	Clackmannanshire
Cerni	Benedictine	1172	Dorsetshire
Chertsey	Do.	temp. Edgar	Surrey
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Coggeshall	Do.	1142	Essex
Cokersand	Premonstrant	1190	Lancashire
Colchester	Benedictine	1142	Essex
Colunsay	Augustine	1230	Argyleshire
Combe	Cistercian	1150	Warwickshire
Combermere	Do.	1133	Cheshire
Conway	Do.	1185	Caernarvonshire
Coupar	Do.	1164	Forfarshire
Coversham	Premonstrant	14 John	Yorkshire
Cranburn	Benedictine	980	Dorsetshire
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Crossraguel	Cluniac	1244	Ayrshire
Croxden	Cistercian	1176	Staffordshire

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Cumhyre	Do.	1143	Radnorshire
Dale, le	Premonstrant	temp. Hen. II.	Derbyshire
Deer	Cistercian	1218	Aberdeenshire
De la Pre	Cluniac	temp. Steph.	Northamptonshire
Denny	Benedictine	980	Cambridgeshire
Derley	Augustine	temp. Hen. I.	Derbyshire
Dieulacres	Cistercian	1214	Staffordshire
Dorchester	Augustine	1140	Oxfordshire
Dore	Cistercian	temp. Steph.	Herefordshire
Downpatrick . . .	Benedictine	493	Down
Dryburgh	Premonstrant	1152	Roxburghshire
Duisk	Cistercian	1212	Kilkenny
Dumfermling . . .	Benedictine	1124	Fifeshire
Dunbrody	Cistercian	1178	Wexford
Dundrenan . . .	Do.	1142	Kirkcudbright
Dunkeswell	Do.	1201	Devonshire
Dureford	Premonstrant	1169	Sussex
Egliston	Do.	temp. Ric. I.	Yorkshire
Eversham	Benedictine	701	Worcestershire
Eynsham	Do.	1005	Oxfordshire
Faringdon	Cistercian	1203	Berkshire
Ferne	Premonstrant	1214	Ross-shire
Ferns	Augustine	1166	Wexford
Feversham	Benedictine	1140	Kent
Flexley	Cistercian	temp. Steph.	Gloucestershire
Ford	Do.	1141	Devonshire
Fountains	Do.	1132	Yorkshire
Frethelstoke . . .	Augustine	8 Hen. III.	Devonshire
Furness	Cistercian	1127	Lancashire
Garendon	Do.	1133	Leicestershire
Glastonbury . . .	Benedictine	954	Somersetshire
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Hagneby	Premonstrant	1175	Lincolnshire
Hales Owen . . .	Do.	temp. John	Shropshire
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Hayles	Do.	1251	Do.
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Hexham	Do.	674	Northumberland
Hilton	Cistercian	1223	Staffordshire
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Holy-Cross	Do.	1182	Tipperary
Holy-Rood	Augustine	1128	Edinburghshire
Home Lacy	Premonstrant	temp. H. III.	Herefordshire
Horton	Benedictine	970	Dorsetshire
Hulme	Carmelite	1240	Northumberland
Humberstayn . . .	*Benedictine*	1226	Lincolnshire

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Hurnston	Benedictine	temp. H. II.	Lincolnshire
Hyde		1110	Hampshire
Icolmkill	Cluniac		Argyleshire
Iespoint	Cistercian	1180	Kilkenny
Inchaffray	Augustine	1200	Perthshire
Inchmahome . . .	Do.	1200	Do.
Inys	Cistercian	1180	Down
Jedburgh	Augustine	temp. Dav. I.	Roxburghshire
Jerval	Cistercian	1156	Yorkshire
Joneval	Do.	1145	Do.
Kelso	Tyrone	1128	Roxburghshire
Kenilworth	Augustine	1122	Warwickshire
Keynsham	Do.	1170	Somersetshire
Kilcooly	Cistercian	1200	Tipperary
Kilwinning	Tyrone	1140	Ayrshire
Kimmer or Cymmer .	Cistercian	1200	Merionethshire
Kingswood	Do.	1139	Wiltshire
Kinner	Do.	1209	Merionethshire
Kirkstall	Do.	1152	Yorkshire
Kirkstead	Do.	1139	Lincolnshire
Kynloss	Do.	1150	Moray
Langdon (West) . .	Premonstrant	1192	Kent
Langley	Do.	1198	Norfolk
Lanthony	Augustine	1136	Gloucestershire
Lavenden	Premonstrant	temp. Hen. II.	Buckinghamshire
Leicester	Do.	1143	Leicestershire
Leiston	Premonstrant	1182	Suffolk
Lesmahagow . . .	Tyrone	1140	Lanarkshire
Lesnes	Augustine	1178	Gloucestershire
Lindores	Tyrone	1178	Perthshire
Llantarnam	Cistercian		Monmouthshire
Lolleshull	Augustine	1145	Shropshire
Louth Park	Cistercian	1139	Lincolnshire
Machline	Do.	temp. Dav. I.	Ayrshire
Malmsbury	Benedictine	675	Wiltshire
Margan	Cistercian	1147	Glamorganshire
Maynan	Do.	1283	Denbighshire
Meaux	Do.	1150	Yorkshire
Medmenham . . .	Do.	1200	Buckinghamshire
Mellifont	Do.	1142	Louth
Melrose	Do.	1136	Roxburghshire
Mereval	Do.	1148	Warwickshire
Michelney	Benedictine	939	Somersetshire
Milton	Do.	933	Dorsetshire
Missenden	Augustine	1133	Buckinghamshire
Neath	Cistercian	temp. Hen. I.	Glamorganshire
Nerminster	Do.	1138	Northumberland
Netley	Do.	1239	Hampshire
Newbo	Premonstrant	1198	Lincolnshire
Newbottle	Cistercian	1140	Edinburghshire
Newenham	Do.	1246	Devonshire
Newhouse	Premonstrant	1143	Lincolnshire
Newry	Cistercian	1150	Down

NAME.	ORDER.	DATE.	COUNTY.
Northampton . . .	Augustine	1112	Northamptonshire
Nutley	Do.	1162	Buckinghamshire
Oransey	Augustine	St. Columba	Argyleshire
Osney	Do.	1129	Oxfordshire
Osulveston	Do.	1175	Leicestershire
Owney	Cistercian	1205	Limerick
Owrston	Templars	temp. Hen. II.	Leicestershire
Paisley	Cluniac	1164	Renfrewshire
Pershore	Benedictine	984	Worcestershire
Pipwell	Cistercian	1143	Northamptonshire
Quarre	Do.	1132	Hampshire
Radmore	Do.	1140	Staffordshire
Ramsey	Benedictine	969	Huntingdonshire
Reading	Do.	1121	Berkshire
Revesby	Cistercian	1142	Lincolnshire
Rewley	Do.	1280	Oxfordshire
Rivaux	Do.	1131	Yorkshire
Robertsbridge . . .	Do.	1176	Sussex
Roche	Do.	1147	Yorkshire
Roncester	Augustine	1146	Staffordshire
Rosglas	Cistercian		Ireland
Rufford	Do.	1148	Nottinghamshire
Russen	Do.	1098	Isle of Man
Saffron Walden . .	Benedictine	1136	Essex
Salley	Cistercian	1146	Yorkshire
Saltry	Do.	1146	Huntingdonshire
Saundle	Do.	1164	Argyleshire
Scone	Augustine	1114	Perthshire
Selby	Benedictine	1069	Yorkshire
Shaftesbury . . .	Do.	888	Dorsetshire
Shap	Premonstrant	temp. Hen. II.	Westmoreland
Shireburn	Benedictine	705	Dorsetshire
Shrewsbury . . .	Do.	1083	Shropshire
Sibton	Cistercian	1149	Suffolk
Spalding	Benedictine	1052	Lincolnshire
Stanlaw	Cistercian	1172	Cheshire
Stanley	Do.	1151	Wiltshire
Stoneley	Do.	1154	Warwickshire
St. Agatha	Premonstrant	1151	Yorkshire
St. Alban's . . .	Benedictine	793	Hertfordshire
St. Augustine . . .	Do.	605	Kent
St. Bennet of Hulme	Do.	1020	Norfolk
St. James	Augustine	1112	Northampton
St. John's, Colchester	Benedictine	1096	Essex
St. Mary	Cistercian	1139	Dublin
St. Mary	Augustine	temp. Ed. III.	Drogheda
St. Mary de Grace .	Cistercian	1349	Middlesex
St. Mary de Pré . .	Augustine	1143	Leicestershire
St. Mary de Valle Salutis . . .	Cistercian	temp. Ed. III.	Ireland
St. Radegund . .	Premonstrant	1191	Kent
Strada Florida, or Stratfleur . .	Cistercian	1294	Cardiganshire

NAME.	ORDER.	DATE.	COUNTY.
Stratford Longthorne	Cistercian	1134	Essex
Stratmargel, or Strata Marcella	Do.	1170	Montgomeryshire
Sulby	Premonstrant	1155	Northamptonshire
Sweetheart, or New	Cistercian	1296	Kirkcudbright
Swine	Do.	temp. Steph.	Yorkshire
Swineshead	Do.	1134	Lincolnshire
Talley	Premonstrant	1197	Carmarthenshire
Tame	Cistercian	1137	Oxfordshire
Tavistock	Benedictine	961	Devonshire
Tewkesbury	Do.	1102	Gloucestershire
Thorneton	Augustine	1139	Yorkshire
Thorney	Benedictine	972	Cambridgeshire
Tiltey	Cistercian	1152	Essex
Tintern	Do.	1131	Monmouthshire
Tintern	Do.	1308	Wexford
Titchfield	Premonstrant	1231	Hampshire
Torr	Do.	1196	Devonshire
Tungland	Do.	1160	Kirkcudbright
Tupholm	Do.	temp. H. II.	Lincolnshire
Vale Royal	Cistercian	1266	Cheshire
Valle Crucis	Do.	1200	Denbighshire
Vaudey	Do.	1147	Lincolnshire
Waltham Abbey	Augustine	1062	Essex
Wardon	Cistercian	1135	Bedfordshire
Waverley	Do.	1128	Surrey
Wearmouth	Benedictine		Durham
Welbeck	Premonstrant	1153	Nottinghamshire
Wellow	Augustine	temp. Hen. I.	Lincolnshire
Wendling	Premonstrant	temp. H. III.	Norfolk
West Dereham	Do.	1188	Do.
West Ham	Cistercian	1135	Essex
Westminster	Benedictine	1049	Middlesex
Westwood	Augustine	1178	Kent
Whalley	Cistercian	1296	Lancashire
Whitby	Benedictine	Wm. Conq.	Yorkshire
Whiteland	Cistercian	1143	
Wigmore	Augustine	1179	Herefordshire
Winchcombe	Benedictine	985	Gloucestershire
Windham	Do.	1107	Norfolk
Woburn	Cistercian	1145	Bedfordshire

Abbey gate-house, a lodge for warders or porters at the entrance of an abbey edifice

Abbot, the superior of a monastery of monks erected into an abbey or priory: there are various classes of abbots, as mitred, crosiered, cardinal, regular, and commendatory abbots

Abbot's lodgings, in the early times of *English ecclesiastical* architecture, a complete house, with hall, chapel, and every convenience for the residence of a spiritual baron

Abbreviate, to contract a word in writing or printing

Abbreviations, characters or marks over letters to signify either a word or syllable

Abele-tree, a species of white poplar

Aberration, in astronomy, an apparent motion of the celestial bodies oc-

casioned by the progressive motion of light and the earth's annual motion in its orbit

Aberration, in optics, the deviation or dispersion of the rays of light when reflected by a lens, by which they are prevented from meeting or uniting in the same point, called the geometrical focus; but spread over a small span, they produce a confusion of images

Ablactation, in gardening, the method of grafting

Ablaqueation, the opening of the ground around the roots of trees, for the admission of the air

Aboard, a nautical term, the inside of a ship, or to go on board

About-ship, the situation of a ship after she has tacked

About-sledge, the largest hammer employed by smiths; it is slung round near the extremity of the handle, and generally used by under workmen, called hammer-men

Abrasion, the effect produced by attrition or rubbing

Abreast, as when two ships have their sides parallel

Abreuvoir, a watering-place

Abreuvoir, in masonry, the interstice or joint between two stones to be filled up with mortar or cement

Abscissa, a geometrical term for a segment cut off from the straight line by an ordinate to a curve

Absorbents, in chemistry, those earthy substances capable of uniting, by capillary attraction, a large proportion of water: such are magnesia, lime, and clay, when dry and porous

Absorption, in chemistry, takes place when, by the combination of gases with other substances, a very considerable diminution of volume is experienced: it differs from condensation

Abstract (*To*), a term used by artificers and surveyors in arranging and apportioning their work, to explain and price it

Abstract mathematics, otherwise denominated pure mathematics, that branch of the science which treats of simple properties, magnitude, figure, or quantity, absolutely and generally considered

Absurd, a term used in demonstrating converse propositions

Abundant number, a number whose aliquot parts, added together, make a sum which is greater than the number itself

Abuses. "Architecture," says Palladio, "being an imitatrix of Nature, delights in that which is most consonant with her prototype." Ancient edifices were built with wood, trees forming the columns; and when architects began to build with stone, they made the columns to imitate the trunks of trees, tapering from their bases. Being thus originally of wood, and therefore liable to split when much loaded, they bound them with rings at top and bottom. Thus the bases and capitals in the different orders seem originally derived from these bandages, though they are now become essential ornaments. Thus also in entablatures, the triglyphs, modillions, and dentils represent the ends of those beams and timbers which are employed for the support of the floors and roofs. If, therefore, all these conditions be duly considered, those practices in building are highly to be reprobated which are in opposition to that analogy which should exist between the original and its imitation, or which depart from Nature and the simplicity observable in all her works.

Consoles or cartouches, which are of a scroll-like form, should never be employed for the apparent support of great weights, in place of columns or pilasters; nor should they ever project from, or spring out of, cornices.

Pediments and frontispieces over doors and windows, or elsewhere, should on no account be broken or disconnected in the middle; for the intention of these is to shelter the parts below from the rain, and

this result is completely obviated by such a practice.

The projecture of cornices, though for the purpose of sheltering buildings, should not be more than in due proportion to their height, whether or not accompanied by columns; for if too heavy, they seem to threaten with danger those who are under them; and if too small in projection, they do not properly perform their office.

Again, those columns which are feigned to be composed of several pieces, by being jointed together with rings, should be carefully avoided, because the more solid and strong the columns appear, the better they seem to answer the purpose for which they were erected, which is securely to receive the superincumbent loading.

There are many other abuses which the authority of great masters may sanction, but not justify; and such will readily occur to the student, and themselves point out that they ought to be avoided

Abutment, the solid part of a pier from which the arch springs

Abutments, the extremities of a bridge, by which it joins upon the banks or sides of a river, &c.: in carpentry and joinery, the junctions or meetings of two pieces of timber, of which the fibres of the one run perpendicular to the joint, and those of the other parallel to it

Abuttals, the buttings or boundaries of land

Abyss, in heraldry, the centre of an escutcheon

Acacio, a heavy, durable wood of the red mahogany character, but darker and plainer; it is highly esteemed in ship-building

Academia, in antiquity, a villa or pleasure-house in one of the suburbs of Athens, where Plato and other philosophers assembled

Academician, a member of a society or academy instituted for the cultivation of the arts and sciences

Acanthus, the plant branca ursina, in English *bear's breech*, the leaves of which are imitated in decorating the Corinthian and Composite capitals of columns

Accelerated motion, a force acting incessantly upon a body; called also a constant or uniformly accelerating force when the velocity increases equally in equal times: the force of gravity near the earth's surface is of this kind; it generates a velocity of $32\frac{1}{6}$ feet in each second of time; that is, a body, after falling one second, acquires a velocity of $32\frac{1}{6}$ feet; after falling two seconds, it will acquire a velocity of $2 \times 32\frac{1}{6}$ feet; after three seconds, a velocity of $3 \times 32\frac{1}{6}$ feet, and so on

Accelerating force, in physics, the force which accelerates the motion or velocity of bodies; it is equal to, or expressed by, the quotient arising from the motion or absolute force, divided by the mass or the weight of the body moved

Accelerative or *retardative force*, is commonly understood to be that which affects the velocity only, or that by which the velocity is accelerated or retarded; it is equal or proportional to the motive force directly, and to the mass or body moved inversely

Accesses, approaches or passages of communication between the various apartments of a building, as corridors

Accessible, in surveying, a place which admits of having a distance or length of ground measured from it; or such a height or depth as can be measured by the application of a proper instrument

Accessories, or *accompaniments*, in painting, secondary objects to the principal one in a picture, introduced as explanatory and illustrative of the scene: sometimes they are considered as solely contributing to the general effect and harmony of the piece

Accidental point, in perspective, the point in which a right line drawn from the eye, parallel to another

right line, cuts the picture or perspective plane

Acclivity, the slope or steepness of a line or plane inclined to the horizon, taken upwards; in contradistinction to declivity, which is taken downwards

Accouplement, in carpentry, a tie or brace, or the entire work when framed

Accretion, in physics, the growth or increase of an organized body

Accroché, in heraldry, denotes the hanging of one thing upon another

Accubitus, a room annexed to large churches, in which the clergy occasionally reposed

Aceric acid, in chemistry, an acid formed from the juice of the maple-tree

Acerra, in antiquity, an altar erected, among the Romans, near the bed of a person deceased, on which his friends daily offered incense until his burial

Acetate of lead,—sugar of lead,—a compound of acetic acid and lead

Acetate of potash, a compound of acetic acid and potash, produced by dissolving carbonate of potash in distilled vinegar

Acetates, crystallizable salts, formed by the combination of any base with acetic acid, named also radical or pure vinegar

Achromatic, a term expressing absence of colour: in optics, applied to telescopes invented to remedy aberrations and colours

Acids, in chemistry, are sour to the taste, and convert vegetable blues to a red colour; they combine with alkalies, earths, and metallic oxides, and form, with them, the well-known compounds named *salts*

Acinose, a term applied to iron ore found in masses, and of several colours

A-cock-bill, in navigation, the situation of the yards when they are topped up at an angle with the deck; the situation of an anchor when it hangs to the cat-head by the ring only

Acolyte, in the ancient church, a person who trimmed the lamps, prepared for the sacrament, &c.

Acoustics, the doctrine or theory of sounds, consisting of diacoustics, or direct sounds, and catacoustics, or reflecting sounds

Acre, a measure of land, containing, by the ordinance for measuring land in the time of Edward I., 160 perches or square poles of land; and as the statute length of a pole is 5½ yards or 16½ feet, the acre contains 4840 square yards, or 43560 square feet. The chain with which land is now commonly measured, invented by Gunter, is 4 poles, or 22 yards, in length; and the acre is therefore just 10 square chains; and as a mile contains 1760 yards, or 80 chains, in length, the square mile is equal to 640 acres. The acre, in surveying, is divided into 4 roods, and the rood into 4 perches

Acrolithes, in sculpture, statues, the extremities of which are formed of stone

Acropolis, a building strictly applicable to a Greek city, and usually erected upon a hill, rock, or some natural elevation, and devoted to a magnificent temple; also a tower, castle, or citadel

Acrostolion, in ancient naval architecture, an ornament of the prow or forecastle of a ship, chiefly of war, most frequently circular or spiral

Acroteria, small pedestals at the angles and vertex of a pediment: the gate of the Agora at Athens is the only instance in which they appear in Grecian buildings

Actinometer: Sir John Herschel, at the third meeting of the British Association, submitted an instrument for measuring at any instant the direct heating power of the solar ray: it affords a dynamical measure of the solar radiation, by receiving a quantity of heat per second, or any short space of time, on a surface exposed to the sun.

In making observations with this instrument, it should be freely exposed in the shade for one minute, and the variation read; afterwards expose it for the same time to the solar action, and again note it; and lastly, repeat the experiment in the shade: the mean of the two variations in the shade being subducted from the variation in the sun, the excess gives the dilatation per minute due to the sun's rays; the quantity subducted being the effect of the other causes at the time

Actus, a Roman measure of length, equal to 120 Roman feet

Acute angle, in geometry, less than a right angle, and measured by less than 90°, or a quadrant of a circle

Acute-angled cone, that in which the opposite sides make an acute at the vertex, or whose axis, in a right cone, makes less than half a right angle with the side

Acute-angled section of a cone, an ellipsis made by a plane cutting both sides of an acute-angled cone

Acute-angled triangle, that in which the three angles are all acute

Adamant, a very hard stone, used by the ancients for cutting and polishing other hard stones and glass

Adeling, a title of honour given to the children of princes among the Anglo-Saxons

Adhesion, the force with which different bodies remain attached to each other when brought into contact

Adit, the passage or approach to a house; applied also to the horizontal shaft of a mine, driven for the purposes of ventilating, watering, or draining

Adit level, in mining, a horizontal excavation through which the water is drawn by the engine

Adjacent angle, in geometry, an angle immediately contiguous to another, so that one side is common to both

Adjutage (*Ajutage*), or *jet d'eau*, a tube fitted to the aperture of a vessel through which water is to be played

Adonia, a festival celebrated in honour of Aphrodite and Adonis in most of the Grecian cities

Adrift, the condition of a vessel broken from her moorings

Adumbration, in heraldry, a figure painted of the same colour as the ground of the field, but darker

Adytum, the most sacred place in the heathen temples; the Holy of Holies; in Christian architecture, the chancel or altar-end of a church

Adze, an edged tool used to chip surfaces in a horizontal direction; the *axe* being employed to chop materials in vertical positions

Æcclesiolo, in Domesday Book, a chapel subordinate to the mother church

Ædes, an inferior kind of temple; in Christian architecture, a chapel; also sometimes applied to a house

Ædicula, a small chapel, house, or building of any kind; not unfrequently applied to the niches of tabernacles in a wall which held statues of the lares or penates

Ægricanes, a name given to rams' heads when sculptured on friezes, altars, &c.

Æolipile, in hydraulics, an instrument consisting of a hollow metallic ball with a slender neck or pipe proceeding from it, which, being filled with water, produces a violent blast of wind

Æolus, a small portable machine for refreshing and changing the air of apartments

Ærarium, a treasury among the Romans; the place where public money was deposited

Aërial perspective, the relative apparent recession of objects from the foreground, owing to the quantity of air interposed between them and the spectator

Aërology, the doctrine or science of the air

Aërometer, an instrument contrived to ascertain the mean bulk of gases

Aërometry, the science of measuring the air, its powers and properties

Aëronautics, the art of sailing or floating in the air

Aërostatics, the doctrine of the weight, pressure, and balance of the air and atmosphere

Ærugo, rust, more especially that of copper; verdigris

Æsthetics, the power of perception by means of the senses: the word implies the perception and the study of those qualities which constitute the beautiful and artistic, and form the finer essence of all productions of fine art. It carries with it, therefore, a more exact and philosophic meaning than the word 'taste.' In its adjective form, in which it more frequently occurs, it is particularly useful, as no adequate epithet can be substituted for it. Thus we speak of the 'æsthetic sense,' of 'æsthetic feeling,' or 'study,' or 'principles,' &c.; but we cannot correctly say the 'tasteful sense,' or 'tasteful study'

Aëtoma, a pediment, or the tympanum of a pediment

Affinity, in chemistry, the power by which the ultimate particles of matter are made to unite, and kept united

Afflux, a flow of electric matter to a globe and conductor, in opposition to *efflux*, from them

After, in ship-building, implies a connexion, as belonging to the afterbody, after-timber, &c.

Agalma, a sculptural ornament or image

Ager, a Roman acre of land

Agger, a heap or mound of any kind, formed of stone, wood, or earth

Agglutination, the cohesion of bodies

Aggregation, in chemistry, the collection of bodies, solid, fluid, or gaseous

Agora, a place of public assembly in a Greek city for the transaction of all public business; a market-place

Aguilla, an obelisk, or the spire of a church tower

A-hull, the condition of a vessel when she has all her sails furled, and her helm lashed a-lee

Air-casing, the sheet-iron casing which surrounds the base of the chimney of a steam vessel, to prevent too great a transmission of heat to the deck

Air-drains, cavities between the external walls of a building, protected by a wall towards the earth, which is thus prevented from causing dampness

Air-escape, a contrivance for letting off the air from water-pipes

Air-holes, those made for admitting air to ventilate apartments

Air-machine, in mining, the apparatus used for forcing purer air into or withdrawing foul air from parts badly ventilated

Air-pipes, in mining, tubes or pipes of iron or wood, for ventilating under ground, or for the conveyance of fresh air into levels having but one communication with the atmosphere, and no current of air: also used for clearing foul air from the holds of ships or other close places

Air-pump, a pneumatic instrument, by means of which the air is exhausted out of the proper vessels: its effects are produced by the elasticity of the air; and as at each stroke of the pump only a part of the remaining air is withdrawn, an absolute vacuum cannot be obtained, although so near an approximation to it may be had as to remove the general effects of the atmosphere. The proportion of the air-pump, as given by Watt, is usually about two-thirds of the diameter of the cylinder, when the length of the stroke of the air-bucket is half the length of the stroke of the steam piston. The area of the passages between the condenser and the air-pump should never be less than one-fourth of the area of the air-pump. The apertures through the air-bucket should have the same proportion; and, if convenient, the discharging flap or valve should be made larger. The capacity of the condenser should at least be equal to that of the air-pump; but, when conveni-

ence will admit of it, the larger it is the better

Air-pump bucket, an open piston, with valves on the upper surface, opening upwards, so as to admit the air and water in the down-stroke, and lift it with the up-stroke of the pump

Air-pump rod, the rod for connecting the bucket to the beam

Air-tint, in painting, the tint by which the distant parts of a landscape are rendered more distinct, or sometimes giving a misty appearance to the whole: it is generally compounded of a blue-grey, occasionally approaching to purple

Air-trap, a trap immersed in water, to prevent foul air arising from sewers or drains

Air-valve, applied to steam boilers for the purpose of preventing the formation of a vacuum when the steam is condensing in the boiler

Air-vessel, the closed cylinder connected to the discharge-pipe of a force-pump, and by the action of which the water ejected by the piston or plunger of the pump enters the cylinder and compresses the air within; it acts as a spring during the return stroke, and thus renders the stream constant: also a chamber containing air, attached to pumps and other water engines, for the purpose of making the discharge constant when the supply is intermittent

Aisle, the side passage or division of a church, partially separated from the nave and choir by columns or piers

Aitre, a hearth or chimney

Alabaster, a species of gypsum, a mineral substance, chemically termed *sulphate of lime:* also a box or vase for holding perfumes and ointments; so called because originally made of alabaster, and for which the variety called *onyx-alabaster* was usually employed

Alba, a beacon or light-house

Albarium, white-wash; according to *Pliny and* Vitruvius, a white stucco or plaster, made of a pure kind of lime burned from marble, and used to spread over the roofs of houses

Albarium opus, according to Vitruvius, a species of stucco-work

Alcahest, in ancient chemistry, a universal dissolvent

Alcha, a cellar, pantry, or an apartment for the reception of drinking vessels

Alchemist, one skilled in the art of alchemy or chemistry

Alchemy, that branch of chemistry which presumes the transmutation of metals: Lord Bacon calls it the art of distilling or drawing quintessences out of metals by fire

Alcohol, in chemistry, a pure spirit

Alcoholometer, an instrument for ascertaining the strength of spirits

Alcorans, in oriental architecture, high slender towers attached to mosques, in which the Koran is read

Alcove, a recess in a chamber, or a recess separated from other parts of the room by columns, antæ, and balusters

Alder, a wood formerly much used. The common alder seldom exceeds 40 feet in height, is very durable under water, and was used for the piles of the Rialto at Venice, the buildings at Ravenna, &c.: it was formerly much used for pipes, pumps, and sluices

Aleaceria, a palace, castle, or other large edifice

Aleatorium, an apartment in a Roman house appropriated to the use of persons playing with dice

A-lee, a term used to denote the position of the helm when it is put in the opposite direction from that in which the wind blows

Alembic, in chemistry, a vessel used in distillation

Aleois, loopholes in the walls of a castle or fortification, through which arrows may be discharged

Algaroth, in chemistry, a white powder obtained from muriate of antimony

Algebra, literal arithmetic, or the

science by which quantity, and the operations of quantity, are expressed by conventional symbols

Alhambra, in Saracenic architecture, the royal palace of the kings of Granada

Alien Priories, cells or small religious houses erected in different countries, and distinguished as *alien* from their dependence on large foreign monasteries. The following is a list of those established in England, with the dates of their foundation:

NAME.	ORDER.	DATE.	COUNTY.
Ailey	Benedictine	1160	Herefordshire
Alberbury	Do.	Henry I.	Shropshire
Allerton Mallever	Do.	1364	Yorkshire
Andewell	Do.		Hampshire
Andover	Do.	Wm. Conq.	Do.
Appledercomb	Do.	Henry III.	Isle of Wight
Astley	Do.	1160	Worcestershire
Avebury	Do.	Wm. Conq.	Wiltshire
Axmouth	Do.	Henry II.	Devonshire
Beccanford	Augustine		Gloucestershire
Begare		Henry III.	Yorkshire
Birstall	Benedictine	1115	Do.
Blakenham	Do.	Wm. Rufus	Suffolk
Brimsfield	Do.		Gloucestershire
Burne (College of)	Do.	1200	Kent
Burwell	Do.	1318	Lincolnshire
Cameringham	Premonstrant	Richard II.	Do.
Carisbrook	Benedictine	1071	Isle of Wight
Charleton	Premonstrant	1187	Wiltshire
Charlton upon Otmoor		1081	Oxfordshire
Clare	Benedictine	1090	Suffolk
Clatford	Do.	Wm. Conq.	Wiltshire
Cogges	Black Monks	1103	Oxfordshire
Cosham	Benedictine	King Steph.	Wiltshire
Covenham	Do.	1082	Lincolnshire
Cowike	Do.	Henry II.	Devonshire
Cresswell	Do.	King John	Herefordshire
De la Grave	Do.	1169	Bedfordshire
Ecclesfield	Do.		Yorkshire
Edith Weston	Do.	Henry I.	Rutlandshire
Elingham	Do.	1163	Hampshire
Fieldallying	Cistercian	Henry II.	Norfolk
Frampton	Black Monks	King Steph.	Dorsetshire
Goldcliff	Benedictine	1113	Monmouthshire
Grosmont	Do.	King John	Yorkshire
Hagham	Cluniac	Richard II.	Lincolnshire
Haghe	Benedictine	1164	Do.
Hamele	Cistercian		Hampshire
Hinckley	Benedictine	1173	Leicestershire
Horkeslegh	Do.	Wm. Conq.	Gloucestershire
Hou	Do.	1096	Sussex
Ipilpen	Do.	1274	Devonshire
Lancaster	Do.	1004	Lancaster
Lappele	Black Monks	Edw. Conf.	Staffordshire
Lavenestre	Benedictine	Wm. Conq.	Sussex

NAME.	ORDER.	DATE.	COUNTY.
Lesingham		Wm. Rufus	Norfolk
Lewisham	Benedictine	before Conq.	Kent
Limburgh Magna . .	Cistercian	Richard II.	Lincolnshire
Llangewith	Benedictine	King Steph.	Glamorganshire
Llangkywan . . .	Black Monks	1183	Monmouthshire
Lodnes	Benedictine	Henry I.	Dorsetshire
Long Bengton . . .	Do.	1175	Lincolnshire
Lynton		1255	Cambridgeshire
Mersey	Benedictine	Edw. Conf.	Essex
Minster Lovel . . .	Do.	1259	Oxfordshire
Minting	Do.	1129	Lincolnshire
Modbury	Do.	1275	Devonshire
Monkenlane . . .	Do.	Richard II.	Herefordshire
Monks Kirby . . .	Do.	1077	Warwickshire
Okeburn	Do.	1149	Wiltshire
Okerington	Do.	Wm. Conq.	Devonshire
Overdon		1217	Northamptonshire
Newington Longeville	Benedictine	Henry I.	Buckinghamshire
New Romney . . .	Do.		Kent
Noent	Do.	Wm. Conq.	Gloucestershire
Paunsfield	Do.	King Steph.	Essex
Povington			Dorsetshire
Riselipp	Do.	Wm. Rufus	Middlesex
Rotherfield		800	Sussex
Scardeburgh . . .	Cistercian	King John	Yorkshire
Sidmouth	Benedictine	Wm. Conq.	Devonshire
Spedtesbury . . .	Carthusian	Henry I.	Dorsetshire
Sporle	Black Monks	1256	Norfolk
Stayning		Sax. period	Sussex
Steventon	Black Monks	Henry I.	Berkshire
Stoke Curcy . . .	Benedictine	Henry II.	Somersetshire
Stratfieldsay . . .	Do.	1170	Berkshire
St. Clare	Cluniac		Carmarthenshire
St. Cross		1153	Isle of Wight
St. Helen's	Do.	1155	Do.
St. Michael's Mount .	Benedictine	1085	Cornwall
Sumpting			Sussex
Swavesey	Do.	Wm. Conq.	Cambridgeshire
Takeley		Edward I.	Essex
Talcarr			Cornwall
Thurlegh	Cell of Monks		Kent
Tofte	Benedictine	Henry I.	Norfolk
Tooting	Black Monks	Wm. Conq.	Surrey
Tregony		1267	Cornwall
Tykeford	Benedictine	Wm. Rufus	Buckinghamshire
Uphaven		King Steph.	Wiltshire
Ware		1081	Hertfordshire
Wareham		Henry I.	Dorsetshire
Warmington . . .	Do.	Henry I.	Warwickshire
Wedon on the Street.		Wm. Conq.	Northamptonshire
Wedon Pinkney . .	Do.	Henry I.	Do.
Welles	Do.	Wm. Conq.	Norfolk
Wenge	Do.		Buckinghamshire

NAME.	ORDER.	DATE.	COUNTY.
Wenghale		Henry III.	Lincolnshire
West Ravendale . .	Premonstrant	1202	Do.
West Shirburne . .	Benedictine	Henry I.	Hampshire
Westwood	Do.	Henry II.	Worcestershire
Willesford	Do.	King Steph.	Lincolnshire
Wilmington . . .	Do.	Wm. Rufus	Sussex
Winterbury Wast . .	Do.	1214	Dorsetshire
Wirham	Do.	Richard I.	Norfolk
Wolfricheston . . .	Black Monks	Wm. Conq.	Warwickshire
Wolton Wawm . .	Benedictine	Henry I.	Do.

Alipterion, in ancient Rome, a room wherein bathers anointed themselves

Aliquot part, such part of a number as will exactly divide it without a remainder; a part as, being taken or repeated a certain number of times, exactly makes up or is equal to the whole: thus 1 is an aliquot part of 6 or any other whole number

Alkalescent, a chemical term applied to such animal and vegetable substances as have a tendency to produce muriate of ammonia, or volatile alkali

Alkali, in chemistry: potash and soda were usually termed fixed, and ammonia volatile, alkalies: alkalies combine with and neutralize acids, thereby producing salts; they also change vegetable blues to green

Alkalimeter, an instrument for measuring and determining the quantity and strength of alkalies

Allette, used to express a small wing of a building; also applied to a pilaster or buttress

Alley, a passage from one part of a building to another; a passage or court with houses

Alligation, one of the rules of arithmetic, by which are resolved questions which relate to the compounding or mixing together of divers simples or ingredients

Allorium, a piazza, corridor, or covered way in the flank of a building

Alloy, baser metal, commonly mixed with the precious metals

Alluvium, the débris occasioned by causes still in operation, as deposits left by *the action of rivers, floods, and torrents*

Almacantar, lines parallel to the horizon, and conceived to pass through every degree of the meridian

Almehrab, a niche in the mosques of the Arabs, for praying

Almond-tree, a hard, heavy, oily or resinous kind of wood, somewhat pliable

Almonry, a room or place where alms were formerly distributed to the poor

Almshouse, a house for the reception and support of the poor

Aloof, in navigation, to keep the ship near the wind when sailing upon a quarter wind

Alquifore, lead ore found in Cornwall, and used by potters to green varnish their wares

Alrunæ, small images carved out of roots of trees, and anciently held in much veneration by the northern nations

Altar, an elevated table of either stone, marble, or wood, dedicated to the ceremonies of religious worship. "And Noah builded an altar unto the Lord; and took of every clean beast, and of every clean fowl, and offered burnt offerings on the altar."—*Gen.* viii. 20.

Altar-piece, the ornamental sculpture or painting behind the altar in a Christian church

Altar-screen, the back of an altar, or the partition by which the choir is separated from the presbytery and lady-chapel

Altars, among the Greeks, according to Wilkins's 'Vitruvius,' faced the east, and were placed lower than the statues arranged about the cella.

in order that those who offered up prayers and sacrifices might know, from their different heights, to what particular deities the several altars were consecrated

Altare chori, a reading desk in a church

Altare farum, the lustre, chandelier, or cresset, suspended over an altar

Altimetry, the art of taking or measuring altitudes or heights

Altitude, of a figure, the length of a line drawn perpendicularly from the vertex to the base

Alto-rilievo, highly relieved sculpture representing figures either entirely or nearly detached from the background

Alum, a salt extracted from various minerals called alum ores; of great use to chemists, dyers, and artists; acid and sharp to the taste

Aluminum, in chemistry, the metallic base of the earth alumina, which is found in nature along with some oxides, and acting as an acid: these combinations are termed *aluminates*, and are insoluble in acids

Alveus, in hydrography, the channel or belly of a river

Amalgam, a mixture of mercury with any other metal, tin, lead, &c.

Ambitus, an enclosure, more particularly applied to the space around a building, as a church-yard or a castle-yard

Ambo, *Ambone*, a rostrum or raised platform

Ambulatio, walks, or places of exercise, according to Vitruvius, adjacent to theatres

Ambulatory, a cloister, gallery, or alley

Ammonia, in chemistry, a compound of hydrogen and azote, which can only be exhibited pure in a state of gas; with carbonic acid, it forms volatile alkali or hartshorn. Ammonia is found in the urine of animals, in the earth, and also in the atmosphere: it was formerly obtained by distilling horn, from which it acquired the name of *hartshorn. It is generally* prepared *from chloride of* ammonium or sal-ammoniac, from which it receives its name

Ammoniac, a gum used for metallic vessels

Amphiprostyle, a term applied to a temple with a portico in front and also behind

Amphitheatre, an edifice formed by the junction of two theatres at the proscenium, so as to admit of seats all round the periphery

Amphitheatre, in Roman antiquity, a large edifice of an elliptic form, with a series of rising seats or benches disposed around a spacious area, called the arena, in which the combats of gladiators and wild beasts, and other sports, were exhibited. It consisted exteriorly of a wall pierced in its circumference by two or more ranges of arcades, and interiorly of vaulted passages radiating from the exterior arcades towards the arena, and several transverse vaulted corridors which opened a free communication to the stairs at the ends of the passage and to every other part of the building; the corridors and ranges of seats forming elliptical figures parallel to the boundary wall

Amphithura, in the Greek Church, the veil or curtain opening to the folding doors, and dividing the chancel from the rest of the church

Amphora (pl. *amphoræ*), an earthen vase or jar, with a handle on each side of the neck; among the ancients, the usual receptacles of olives, grapes, oil, and wine. Hence, in decoration, *amphoral* means, shaped like an amphora or vase

Amulet, in decoration, a figure or character to which miraculous powers were supposed to be attached, and which particularly distinguished the buildings of Egypt

Amussium, anciently a carpenter's and mason's instrument, the use of which was to obtain a true plane surface; but the statements of the ancient writers render its construction extremely difficult

Amylum, in chemistry, starch

Anabathra, steps to any elevated situation, as the anabathra of theatres, pulpits, &c.

Anabathrum, a pulpit, desk, or high seat

Anacampteria, the lodgings of persons who fled for sanctuary to privileged religious houses

Anacamptics, the doctrine of reflected light

Anachorita, the cell of a hermit

Anaclastics, the doctrine of refracted light

Anaglyph, an engraved, embossed, or chased ornament

Anaglypha, chased or embossed vessels made of bronze or the precious metals, which derived their name from the work on them being in relief, and not engraved

Anaglyphic work, a species of sculpture wherein figures are made prominent by embossing

Analemma, a projection of the meridian; used also to designate a wall, pier, or buttress

Analogium, a tomb over the bodies of saints; also a term formerly applied to pulpits wherein the gospels and epistles were read

Anamorphosis, a distorted piece of perspective, occasioned by too near a point of view, and from the injudicious attitude or situation of the object, but perfectly true according to the laws of perspective

Anchor, an instrument used for the mooring of ships; in architecture, a decorative moulding used in the orders, and applied to the echinus; also an ornament in the form of the fluke of an anchor, frequently cut in the ovolo of Ionic capitals, and in the bed-mouldings of Ionic and Corinthian cornices

Anchor-stock, in ship-building, a method of working planks, by which the abutments are to be disposed near the middle of those planks which are above or below them

Ancon, in decoration, a carved drinking-cup or horn; an elbow or angle, or *corner-stone. The Ancona foot measure is 1·282 of an English foot*

Ancone, a console or ornament cut on the key-stone of an arch

Ancones, trusses or consoles employed in the dressings of apertures; also used to signify the corners or quoins of walls, cross-beams, or rafters, &c.

Andirons, iron bars with legs to support logs of wood in fire-places

Android, in mechanics, an automaton

Andron, an apartment, cloister, or gallery, assigned to the male part of a monastic establishment; applied also to the space in a church by which the men were separated from the women

Anemography, a description of the winds

Anemometer, an instrument for measuring the force of the wind

Anemoscope, a machine to denote the changes of the wind or weather

Angiportum, among the ancients, a narrow lane between two rows of houses

Angle, in geometry, the mutual inclination of two lines meeting in a point

Angle-bar, in joinery, the upright bar at the angle of a polygonal window

Angle-bead, a vertical bead, commonly of wood, fixed to an exterior angle, and flush with the surface of the plaster, &c. of rooms, arches, &c.

Angle-brace, in carpentry, timber fixed to the two extremities of a piece of quadrangular framing, making it to partake of the form of an octagon

Angle-bracket, a bracket placed in the vertex of an angle, and not at right angles with the sides

Angle-capital, used in Ionic capitals to the flank columns which have their volutes placed at an angle of 45° with the planes of the front and returning friezes

Angle-float, in plastering, a float made to any internal angle to the planes of both sides of a room

Angle-modillion, a modillion placed in a direction parallel to a diagonal drawn through a cornice at its mitreing

Angle of application, the angle which

the line of direction of a power gives the lever it acts upon

Angle of inclination, the angle an inclined plane makes with the horizon

Angle of traction, the angle which the direction of a power makes with the inclined plane

Angular perspective, a term applied to the horizontal lines, both of the front and end of a building, converging to vanishing points, and terminating in the horizon; it is sometimes called *oblique* perspective

Anhydrous sulphuric acid, pure sulphuric acid, in the form of a crystalline solid

Annealing, the process of softening and restoring the malleability of metals, by heating and allowing them to cool very slowly; and by which means glass, cast iron, and steel may be united to other substances

Annotto, in chemistry, a reddish-yellow vegetable dye, obtained from the seeds of the bixa orellana, and used for colouring cheese

Annular engine, a direct-action marine engine, having two concentric cylinders; the annular space is fitted with a piston which is attached to a T-shaped cross-head by two piston-rods: the cross-head is formed by two plates with a space between for the connecting-rod to vibrate, and the lower end slides within the inner cylinder, and is connected to the crank. This arrangement has been patented by Messrs. Maudslay

Annular vault, a vaulted roof supported on circular walls

Annulated columns, those clustered together or joined by rings or bands

Annulet, in architecture, a small square member in the Doric capital; also the name of a small flat moulding

Antæ, square pilasters terminating the walls of a temple: when a temple had no portico in front, two columns were made to intervene between the antæ, and the aspect of the temple was said to be *in antis*

Ante-chamber, a room or passage to an inner chamber, for the accommodation of servants and persons in waiting

Ante-capitulum, part of a cloister before the door of a chapter-house

Antefixæ (by some called *Greek tiles*), upright ornamental blocks placed at intervals on the cornice along the side of a roof, to conceal or rather terminate the ridges formed by the overlapping of the roof tiles; also heads of lions, &c., for water spouts, below the eaves of temples

Antemural, a term applied to the outward wall of a castle; or that which separates a presbytery from a choir; also to a barbican entrance before a castle

Antepagmenta, or *Antepagmentum*, the jamb of a door-case

Ante-parallels, in geometry, lines which make equal angles with two other lines, but in a contrary direction

Ante-portico, a term sometimes used to denote an outer porch or vestibule; the *propylæum* in classic architecture

Anterides, buttresses for strengthening walls

Ante-solarium, a balcony facing the sun

Ante-venna, an awning or projecting roof of wood-work; a wooden or pent-house before a shop

Anthepsa, a Grecian vessel used for boiling water or keeping it hot; a cooking utensil

Anthracite, a coal not bituminous, found principally in South Wales and in the United States

Antics, in architecture, figures of men, beasts, &c., placed as ornaments to buildings

Anticum, a porch before a door

Antilia, an ancient machine similar to the modern pump

Antimensium, a portable altar or consecrated table, used as a substitute for a proper altar

Antimeter, an optical instrument for measuring angles

Antimony, a metal usually found in a crude state combined with sulphur, of a bluish-white colour, crystalline texture, brittle, and easily pulverized. It does not oxidate at ordinary temperatures in the air, but, when heated, it burns with a light flame, producing the oxide; it fuses at 800°, and volatilizes at a white heat

Antimony yellow, a preparation of antimony, of a deeper colour than Naples yellow, and similar in its properties: it is principally used in enamel and porcelain painting, and is very various in tint; that of a bright colour is not affected by foul air, although blackened by sugar of lead

Antipagments, ornaments in carved work on the architrave, jambs, posts, or puncheons of doors

Antiquarium, a repository for antique monuments

Antrellum, a small cave or grotto; also a small temple

Antrum, an early temple for Christian worship

Antrum tumbale, a sepulchral cave or grotto

Antwerp blue, light-coloured, and somewhat brighter than Prussian blue, or ferro-prussiate of alumine, having more of the terrene basis, but all the other qualities of that pigment, except its extreme depth. Haarlem blue is a similar pigment

Antwerp brown, a preparation of asphaltum ground in strong drying oil, by which it becomes less liable to crack

Anvil, a large block of iron with a very hard smooth horizontal surface on the top, in which there is a hole at one end, for the purpose of inserting various tools, and a strong steel chisel, on which a piece of iron may be laid, and cut through by a blow with a hammer

A-peek, a nautical term implying that the cable is hove taut, so as to bring the vessel nearly over her anchor: the yards are *a-peek* when they are topped up by contrary lifts

Aperture, an opening in a wall, doorway, or window

Apex, the top or highest point of a cone, mountain, pyramid, spire, roof, &c.

Apiary, a place where bees are kept

Aplome, a mineral of a deep orange colour

Aplustre, in early naval architecture, a carved tablet fixed on the extremity of a ship's head

Apodyterium, a dressing-room or anteroom to a bath in Roman villas, contiguous to the *laconicum*

Apophyge, in architecture, that part of a column between the upper fillet of the base and the cylindrical shaft, which is usually curved into it by a concave sweep or inverted cavetto

Apostles (the) of Jesus Christ were his chief disciples, whom he invested with his authority, filled with his spirit, and instructed particularly in his doctrines and services: they were chosen to raise the edifice of his church; and, after his resurrection, sent into all the world, commissioned to preach, to baptize, and to work miracles. The names of the twelve were,—1. Peter. 2. Andrew. 3. John. 4. Philip. 5. James, major. 6. Bartholomew. 7. Thomas. 8. Matthew. 9. Simon. 10. Jude. 11. James, minor. 12. Judas Iscariot. The last betrayed his master, and having hanged himself, Matthias was chosen in his place

Apotheca, a place in the upper part of the house, in which the Romans frequently placed their wines in earthen amphoræ; also an apothecary's shop, a cabinet, storehouse, &c.

Apothesis, a recess on the south side of the chancel of a church, fitted up with shelves for books, vestments, &c.

Apparatus, a term denoting a complete set of instruments belonging to an artist or a mechanist

Appaumée, in heraldry, to extend the

palm of the hand and the thumb and fingers at full length

Appian way, a celebrated road leading from Rome to Brundusium: so named from Appius Claudius

Appii forum, the forum built by Appius, the Roman consul, about 50 miles distant from Rome, near the modern town of Piperno, on the way to Naples. The uses to which the Romans applied the forum were so various, that it is not easy to ascertain the nature of the building. It might have been a place for the distribution of justice, or for holding a market. The 'Three Taverns' were nearer to Rome than the Appii forum, as Cicero intimates, who, in going from Rome, a little before he came to the forum of Appius, arrived at the Three Taverns; so that probably the chief number of Christians waited for the Apostle Paul at a place of refreshment, while some of their number went forward to meet him and to acquaint him with their expectation of seeing him among them, and for which they respectfully waited his coming. —*Calmet.*

Apple-tree, a wood generally hard and close, and of reddish-brown tints, used commonly in Tunbridge turnery, &c.

Apricot-tree, a native wood of Armenia, used by the French in turnery

Apron, the sill or lower part of a window; a platform or flooring of plank raised at the entrance of a dock: in naval architecture, a piece of curved timber fixed behind the lower part of the stern of a ship

Apsis, the east end of a church or chancel; sometimes applied to a canopy over an altar; also to a circle about a star or planet

Apsis gradata, a bishop's throne in cathedral churches

Apyrous, a chemical term applied to refractory bodies which resist heat

Aqua fortis, in chemistry, nitric acid diluted; the more concentrated is named spirit of nitre

Aquamale, a holy-water basin

Aqua regia, nitro-muriatic acid; a compound of two parts nitric acid and one part muriatic acid

Aquatinta, in the arts, engraving which resembles drawings in Indian ink

Aqua tofano, a poisonous liquor

Aqueduct, a conduit for water: a construction of stone or timber, built on uneven ground, to preserve the level of water, and convey it by a canal from one place to another

Aquemola, a water-mill

Aquila, a reading-desk, so called from its shape being that of an eagle with extended wings, supported by a pedestal

Arabesque, generally applied to a style of ornament for pilasters, friezes, &c., as those painted by Rafaelle in the Vatican

Arabo-tedesco, a term applied to the Moorish style of buildings in Spain, &c.

Ara dignitatis, an altar at which none but the highest ecclesiastics perform divine rites

Aræostyle, in architecture, the greatest interval or distance which can be made between columns, that is, eight modules or four diameters; also a species of temple which has its columns placed widely asunder

Arbor, a spindle or axis upon which a ring or wheel is turned in a lathe

Arbor Dianæ, in chemistry, crystals formed by the combination of silver and mercury

Arbores, brass branches for lights suspended from ceilings

Arboretum, a grove of trees in a park, pleasure-ground, or garden

Arbor vitæ, a tree which attains to a height of from 40 to 50 feet; its wood is of a reddish colour, very light, soft, and fine-grained, and is much used in house carpentry

Arc, in geometry, part of the circumference of a circle, or any curve lying between two points; a bow, vault, or arch

Arca, a place in a vaulted chamber for sepulchral purposes; an exca-

vation before the basement story of a house; an enclosed space; a chest in which the Romans deposited their money: the word is also used to signify a beam of wood which has a groove or channel hollowed in it from one end to the other

Arcade, a series of recesses with arched ceilings or soffits; a covered passage; in modern appliances, a vaulted avenue, now much in vogue, more particularly in Paris. Arcades, though less magnificent than colonnades, are of extraordinary beauty when well contrived, affording shade from the sun and shelter from the rain. Though not so magnificent as colonnades, they are stronger, more solid, and less expensive. They are proper for triumphal entrances, gates of cities, of palaces, of gardens, and of parks; for public squares, markets, or large courts in general, and for all apertures that require an extraordinary width.

THEIR ORNAMENTS.—The piers of arcades may be decorated with columns, pilasters, niches, and apertures of different forms. The arch itself may be turned either with rock-worked or plain rustic arch stones or voussoirs, or with an archivolt properly moulded. The keystone is generally carved in the form of a console, or sculptured with some head, or the like. The archivolt springs from an impost or plat-band, or sometimes from columns; but this is not to be practised except in cases of the most urgent nature, for it makes neither substantial nor beautiful work.

In arches that are of large dimensions, the keystone should never be omitted; its carving, however, may be dispensed with, if expense be an object. When the piers are decorated with disengaged columns, the entablature must break round over the columns; and the columns, whether engaged or not, should stand either on a pedestal or high plinth, by which means they will not only be kept dry, but their bases will likewise be protected from accidental damage.—Arches must always rise from an impost or a plat-band; and if there be no keystone to the archivolt, its summit should be kept down from the under side of the architrave of the accompanying order, at least half the distance that it would be, were a keystone employed, in order that the disagreeable appearance of the acute angle which it would otherwise form with the architrave may be avoided.

THEIR PROPORTIONS. — The height of arches to the under side of their crowns should not exceed twice their clear width, nor should it be much less; the piers not less than one-third the breadth of the arch, nor more than two-thirds; but the piers at the angles should be wider than the other piers by one-half or one-fourth at least

Arcæ, in Roman architecture, the gutters of the cavedium

Arc-boutant, a kind of arched buttress formed of a flat arch, or part of an arch, and abutting against the feet or sides of another arch or vault, to support them, and prevent them from bursting or giving way

Arcella, in mediæval architecture, a cheese-room

Arch, the curved part of a building, supported at its extremities only, and concave towards the earth; a vaulted roof, or dome, constructed either with bricks, stone, or other materials: the arch of a bridge is formed of segments of a circle, elliptical or catenarian; in Christian architecture, arches display twenty-two varieties of form. — Arches are used in large intercolumniations of spacious buildings; in porticoes, both within and without temples; in public halls, as ceilings, the courts of palaces, cloisters, theatres, and amphitheatres: they also are used to cover the cellars in the foundations of houses and powder-magazines; also as buttresses

and counterforts, to support large walls laid deep in the earth; for triumphal arches, gates, windows, &c.; and, above all, for the foundations of bridges and aqueducts: they are supported by piers, abutments, imposts, &c.—Arches are of several kinds, circular, elliptical, cycloidal, catenarian, &c., according as their curve is in the form of a circle, ellipse, cycloid, catenary, &c.—Arches are to be found in the Greek theatres, stadia, and gymnasia, some of them erected probably 400 years before Christ. The most ancient arches of which we have correct data are those of the cloacæ at Rome. The emperor Hadrian threw a bridge over the Cephisus, between the territories of Attica and Eleusis, on the most frequented road of Greece.

Arch (the theory of). This important subject has exercised the talents and ingenuity of some of the greatest mathematicians in modern times, and many different solutions have been given to the various problems connected with it; but, as the greater part of them are founded on suppositions that have no existence whatever either in nature or practice, they have had a tendency rather to mislead than direct those who are engaged in the operations of bridge-building. Dr. Olinthus Gregory, in the preface to his excellent work on Mechanics, states, that "theoretical and practical men will most effectually promote their mutual interests, not by affecting to despise each other, but by blending their efforts; and further, that an essential service will be done to mechanical science, by endeavouring to make all the scattered rays of light they have separately thrown upon this region of human knowledge converge to one point." Gauthey, speaking of the theory of La Hire, observes that such analytical researches are founded on hypotheses which every day's experi*ence contradicts.* The following are the principal writers on the equilibrium of the arch. In 1691, the celebrated mathematicians, Leibnitz, Huygens, James and John Bernouilli, solved the problem of the catenary curve: it was soon perceived that this was precisely the curve of that should be given to an arch which the materials were infinitely small and of equal weight, in order that all its parts may be in equilibrium. In the 'Philosophical Transactions' for the year 1697, it is stated that David Gregory first noticed this identity; but his mode of argument, though sufficiently rigorous, appears not to be so perspicuous as could be desired. In one of the posthumous works of James Bernouilli, two direct solutions of this problem are given, founded on the different modes of viewing the action of the voussoirs: the first is clear, simple, and precise, and easily leads to the equation of the curve, which he shows to be the catenary inverted; the second requires a little correction, which Cramer, the editor of his works, has pointed out. In 1695, La Hire, in his 'Treatise on Mechanics,' laid down, from the theory of the wedge, the proportion according to which the absolute weight of the materials of masonry ought to be increased from the keystone to the springing in a semicircular arch. The historian of the Academy of Sciences relates, in the volume for the year 1704, that Parent determined on the same principle, but only by points, the figure of the extrados of an arch, the intrados being a semicircle, and found the force or thrust of a similar arch against the piers. In the 'Memoirs of the Academy of Sciences' for the year 1712, La Hire gave an investigation of the thrusts in arches under a point of view suggested by his own experiments: he supposed that arches, the piers of which had not solidity enough to resist the thrust, split towards the haunches

at an elevation of about 45 degrees above the springings or impost; he consequently regarded the upper part of the arch as a wedge that tends to separate or overturn the abutments, and determined, on the theory of the wedge and the lever, the dimensions which they ought to have to resist this single effort. Couplet, in a memoir composed of two parts, the first of which was printed in the volume of the Academy for 1729, treats of the thrusts of arches and the thickness of the voussoirs, by considering the materials infinitely small, and capable of sliding over each other without any pressure or friction. But, as this hypothesis is not exactly conformable to experiment, the 2nd part of the memoir, printed in the volume for 1730, resumes the question by supposing that the materials have not the power of sliding over each other, but that they can raise themselves and separate by minute rotatory motions. It cannot, however, be said that Couplet has added materially to the theories of La Hire and Parent, and none of them treated the subject, either in theory and practice, in such a satisfactory manner as was afterwards done by Coulomb. Subsequently a memoir was published by Bouguer on the curve lines that are most proper for the formation of the arches of domes. He considers that there may be an infinite number of curve lines employed for this purpose, and points out the mode of selecting them. He lays it down uniformly that the voussoirs have their surfaces infinitely smooth, and establishes, on this hypothesis, the conditions of equilibrium in each horizontal course of the dome, but has not given any method of investigating the thrusts of arches of this kind, nor of the forces that act upon the masonry when the generating curve is subjected to given conditions. In 1770, Bossut gave investigations of arches of the different kinds, in two memoirs, which were printed among those of the Academy of Sciences for the years 1774 and 1776: he appears to have been engaged in this in consequence of some disputes concerning the dome of the French Pantheon, begun by the celebrated architect Soufflot, and finished from his designs. In 1772, Dr. Hutton published his principles of bridges, in which he investigated the form of curves for the intrados of an arch, the extrados being given, and *vice versa*. He set out by developing the properties of the equilibrated polygon, which is extremely useful in the equilibrium of structures. Mr. Attwood has written a dissertation on the construction of arches on the same principles as La Hire.

Arch, in architecture, a concave structure raised or turned upon a mould, called the centering, in form of the arc of a curve, and serving as the inward support of some superstructure. Sir Henry Wotton says, "An arch is nothing but a narrow or contracted vault; and a vault is a dilated arch."

Arch, in geometry, a part of any curved line, as of a circle or ellipsis

Arch, in masonry, a part of a building suspended over a hollow, and concave towards the area of the hollow: the top of the wall or walls which receives the first arch-stones is technically called the abutment or springing

Arch, in mining, a piece of ground left unworked

Arch-buttress, a piece of insulated masonry usually named a flying-buttress, extending from the clerestory of a church and over the roof of its aisle, where it rests on the buttress of the outer wall

Arch of equilibration, that which is in equilibrium in all its parts, having no tendency to break in one part more than in another

Arch, triumphal, a building of which an arch is the principal feature,

usually raised to commemorate some great achievement

Archæology, the study of ancient art, but more particularly that of the middle ages

Arched, in mining: the roads in a mine, when built with stones or bricks, are generally arched level drifts

Archeion, a recess in a Grecian temple, for the reception of the treasures of the deity to whom the temple was dedicated

Archeion, in Athens, the office in which the decrees of the people and other state documents were preserved

Archetus, a saw for cutting stones: Muratori used the term for a crane or pulley for raising stones to the upper part of a building

Archimedean screw, a machine invented by Archimedes for raising water; also now applied to propel vessels through water

Architect, a person skilled in the art of building; one who forms, plans, and designs for edifices, conducts the work, and directs the secondary artificers employed; and whose emoluments are generally 5 per cent. on the amount of money expended

Architecture, a science applicable to the art of constructing domestic, ecclesiastical, municipal, palatial, or other buildings, and the adornment of the same according to the rules of the several orders, Doric, Ionic, and Corinthian, also the Tuscan, and Composite, from Roman models, or other styles, each for its purpose, such as is usually called Gothic architecture, and modes subservient to climate and fashion, or caprice. "Architecture," says Palladio, "being grounded upon rules taken from the imitation of Nature, admits of nothing that is contrary or foreign to that order which Nature has prescribed to all things. An architect is not restrained from departing sometimes from common methods or usage, provided such variation be agreeable and natural."

The public at large has a claim over the architecture of a country. It is common property, inasmuch as it involves the national taste and character; and no man has a right to pass off his own barbarous inventions as the national taste, and to hand down to posterity his own ignorance and disgrace to become a satire and a libel on the knowledge and taste of his age. There is perhaps no subject on which persons are more apt to differ in their opinions than on the beauty of a building. In architecture the creative power of Nature herself is the model imitated. It is an art which appeals directly to the understanding, and has not the means of flattering the senses in the same way as the sister arts: hence its productions are not universally appreciated. The beautiful models of Nature, however, are the index and guide of the painter and sculptor: a successful imitation of these models, even without an advance on the part of the artist towards those higher intellectual beauties which distinguish the historical painter, is capable of affecting us with very agreeable sensations. The object of an artist's inquiry is not so much to investigate metaphysically the cause of beauty in the productions of his art, as to study the effects that flow from those which by the common consent of ages are esteemed beautiful, and thus shorten his road by an *a priori* method. It is in this way that he will more readily obtain information on those qualities which act on the understanding and excite our affections by means of the beautiful result they exhibit. These qualities may be classed as follows:

MAGNITUDE AND SOLIDITY, as qualities which affect the eye.

ORDER AND HARMONY, as qualities which affect the understanding.

RICHNESS AND SIMPLICITY, as qualities which excite the affections,—in which taste is the principal guide.

These qualities answer to the three divisions which those who have written on architecture have usually adopted, namely—

CONSTRUCTION, in which the chief requisites are solidity and strength.

DESIGN OR DISPOSITION, in which the principal requisites are order and harmony.

DECORATION, whose requisites are richness or simplicity, according to the nature of the composition.

That there are, however, many other circumstances which tend to the production of an agreeable and beautiful result, is sufficiently obvious: one of them should be more particularly noticed, because there can be no doubt of its influence in the excitement of our admiration of the splendid monuments of Grecian art; it is an association with the times and countries which are most hallowed in our imagination. It is difficult for us to see them, even in their modern copies, without feeling them operate upon our minds, as relics of those polished nations where they first arose, and of that great people by whom they were afterwards borrowed.

The business of an architect requires him rather to be a learned judge than a skilful operator; and when he knows how to direct and instruct others with precision, to examine, judge, and value their performances with masterly accuracy, he may truly be said to have acquired all that most men can acquire: there are but few instances of such prodigies as Michael Angelo Buonarotti, who was at once the first architect, painter, geometrician, anatomist, and sculptor of his time.

Vitruvius furthermore observes, that an art enriched with such variety of knowledge is only to be learned by long and constant application; and advises his contemporaries never to assume the title of architects till they are perfect masters of their own profession, and of the arts and sciences with which it is connected; a caution that even in the present times may perhaps not be unnecessary.

Architecture (the application of the orders of). Among the ancients, the use of the orders was very frequent; many parts of their cities were provided with spacious porticoes, their temples were surrounded with colonnades, and their theatres, baths, basilicæ, triumphal arches, mausolea, bridges, and other public buildings were profusely enriched with columns; as were likewise the courts, vestibules, and halls of their private villas and houses.

In pure architecture, says A. W. Pugin, the smallest detail should have a meaning or serve a purpose; and even the construction itself should vary with the material employed, and the designs should be adapted to the material in which they are executed.

Strange as it may appear at first sight, it is in pointed architecture alone that these great principles have been carried out: we may be enabled to illustrate them from the vast cathedral to the simplest erection. Moreover, the architects of the middle ages were the first who turned the natural properties of the various materials to their full account, and made their mechanism a vehicle for their art. The wonderful *strength* and solidity of their buildings are the result, not of quantity or size of the stones employed, but of the art of their disposition.

On the following page is a synopsis of the proportions of the orders, and of the various examples of each, compiled expressly by Mr. W. H. Leeds for Pugin's edition of Normand's 'Parallel of the Orders.'

Names of the Orders.	Base.			Column.			Capital.			Architrave.			Frieze.		
	diam.	mod.	pt.	diam.	mod.	pt.	diam.	mod.	pt.	diam.	mod.	pt.	diam.	mod.	pt.
TUSCAN.															
Palladio	0	1	0	7	0	0	0	1	0	0	1	5	0	0	26
Scamozzi	0	1	0	7	1	0	0	1	0	0	1	2½	0	1	9
Serlio	0	1	0	6	0	0	0	1	0	0	1	0	0	1	0
Vignola	0	1	0	7	0	0	0	1	0	0	0	25	0	1	5
DORIC.															
Parthenon at Athens	.	.	.	5	1	0	0	0	28	0	1	14½	0	1	19½
Temple of Theseus, do.	.	.	.	5	1	0	0	1	0	0	1	20	0	1	25½
Great Temple at Pæstum	.	.	.	4	0	15	0	1	2⅔	0	1	11½	0	1	2½
Temple of Apollo at Delos	.	.	.	5	0	25	0	0	28½	0	1	20	0	1	7
Portico of Philip, do.	.	.	.	6	0	20	0	0	16	0	1	9	0	1	14
Temple at Corinth	.	.	.	8	0	10	0	0	25¼	0	1	16	.	.	.
Propylæum at Athens	.	.	.	5	1	0	0	0	23	.	.	.	.	.	.
Portico of Augustus, do.	.	.	.	6	0	0	0	0	23	.	.	.	.	.	.
Theatre of Marcellus, Rome	.	.	.	7	1	18	0	1	2½	0	1	1	0	1	16
Doric Order at Albano	.	.	.	7	1	0	0	1	0	0	1	0	0	1	15
Baths of Diocletian	.	.	.	8	0	0	0	1	0	0	1	2	0	1	15
Palladio	0	1	0	8	0	0	0	1	0	0	1	0	0	1	15
Scamozzi	0	1	0	8	1	0	0	1	0	0	1	5	0	1	15
Vignola	0	1	0	8	0	0	0	1	0	0	1	0	0	1	15
Viola	0	1	0	8	0	0	0	1	0	0	1	0	0	1	15
Delorme	0	1	0	8	0	0	0	1	0	0	1	0	0	1	15
IONIC.															
Temple on the Ilissus	0	1	0	8	0	0	0	1	9½	0	1	25	0	1	19
Temple of Minerva Polias, Athens	0	0	25	9	1	0	0	1	13½	0	1	21½	0	1	18½
Temple of Erechtheus, Athens	0	0	23½	9	0	0	0	1	10	.	.	.	.	.	.
Temple of Fortuna Virilis	0	1	0⅔	8	1	2¼	0	0	29	0	1	8½	0	0	28⅔
Theatre of Marcellus	0	1	0	9	0	0	0	1	1½	0	1	13	0	1	6⅓
Baths of Diocletian	0	1	0	8	1	0	0	1	1½	0	1	4	0	0	28
Palladio	0	0	22	9	0	0	0	1	1⅔	0	1	6	0	0	27
Scamozzi	0	0	22	8	1	15	0	0	26½	0	1	15	0	0	28
Vignola	0	0	20	9	0	0	0	1	0½	0	1	7½	0	1	15
Serlio	0	0	20½	7	1	0	0	1	0	0	1	0	0	0	22½
Alberti	0	0	22½	8	0	0	0	1	1½	0	1	0	0	1	0
CORINTHIAN.															
Lantern of Demosthenes, Athens	0	1	8½	10	0	0	1	0	24	0	1	21	0	1	9½
Temple of Jupiter Olympius, do.	0	0	21	9	1	15	1	0	27	0	1	11⅜	0	0	27½
Incantada at Salonica	0	0	25	9	0	15	1	0	11	0	1	16½	0	1	12½
Arch of Theseus, Athens	0	0	23	9	1	0	1	0	15	0	1	12½	0	1	10
Temple of Jupiter Stator, Rome	0	0	20	10	0	6½	1	0	6½	0	1	13½	0	1	13½
Temple of Jupiter Tonans	0	0	22½	10	0	15	1	0	10	0	1	12½	0	1	13
Portico of the Pantheon	0	0	24	9	1	16½	1	0	7⅜	0	1	12⅔	0	1	9½
Interior of the Pantheon	0	0	23½	9	1	4½	1	0	12½	0	1	12	0	1	12
Forum of Nerva	.	.	.	.	.	.	1	0	18	0	1	14	0	1	15
Temple of Antoninus and Faustina	0	0	24	9	1	6½	1	0	8⅔	0	1	13½	0	1	10⅝
Nero's Frontispiece	0	0	20½	10	0	0	1	0	16	0	1	14½	0	1	14½
Arch of Constantine	0	0	24	9	1	7	1	0	6⅔	0	1	15	0	1	10
Temple of Mars the Avenger	.	.	.	.	.	.	1	0	9½	0	1	9⅜	.	.	.
Basilica of Antoninus	0	0	23	10	0	11⅔	1	0	9½	0	1	13½	0	1	10
Temple of the Sibyl, Tivoli	0	0	16½	9	0	25	1	0	0	0	1	0	0	1	9½
Palladio	0	1	0	9	1	0	1	0	0	0	1	8	0	0	23½
Scamozzi	0	1	0	10	0	0	1	0	0	0	1	12	0	1	2
Vignola	0	1	0	10	0	0	1	0	0	0	1	15	0	1	15
Serlio	0	1	0	9	0	0	1	0	0	0	1	0	0	1	7
Alberti	0	1	0	9	0	0	1	0	0	0	1	0	0	1	0
COMPOSITE.															
Arch of Titus	0	0	23	10	0	6	1	0	14½	0	1	16	0	1	14
Arch of Septimius Severus	0	0	20	9	1	10	1	0	5½	0	1	15	0	0	25½
Baths of Diocletian	0	0	22	10	0	29⅔	1	0	11	0	1	14½	0	1	14
Palladio	0	1	1½	10	0	0	1	0	0	0	1	10	0	1	0
Scamozzi	0	1	0	9	1	15	1	0	0	0	1	9	0	1	1½
Vignola	0	1	0	10	0	0	1	0	0	0	1	15	0	1	15
Caryatides of the Temple of *Pandrosus*	.	.	.	5	0	0	0	0	27	0	1	25½	.	.	.

tablature.		Intercolumniation.			Diameter of column.	
mod.	pt.	diam.	mod.	pt.	feet.	inches.
1	14½	.	.	.	.	.
1	22½	.	.	.	.	.
1	0	.	.	.	.	.
1	10	.	.	.	.	.
0	0	2	0	20	6	1 8/10
0	11	2	1	6	6	1 8/10
1	12	2	0	10	7	0·03
0	4½	2	0	25	.	.
1	18	3	1	5	2	5·10
.	.	2	0	15	.	.
.	.	.	.	.	.	.
.	.	.	.	.	4	4·05
1	23¾	.	.	.	.	.
1	20	.	.	.	.	.
0	3	.	.	.	.	.
1	23	2	1	15	.	.
0	7	4	0	11	.	.
0	0	.	.	.	.	.
1	25	.	.	.	.	.
1	25	.	.	.	.	.
0	16	2	0	15	1	9·4
0	17½	3	0	0	2	9·4
.	.	1	1	20	2	3·8
0	17½	2	1	5	3	2
0	25⅔	.	.	.	.	.
1	18	.	.	.	.	.
1	19	2	0	7½	.	.
1	25	.	.	.	.	.
0	15	.	.	.	.	.
0	24½	.	.	.	.	.
1	10	.	.	.	.	.
0	20½	2	0	6	1	2
1	27	3	0	0	2	11·3
0	7¼	3	0	24	2	5′ 9″
0	14	.	.	.	.	.
1	6⅓	1	1	5	4	10 2/10
0	11⅔	1	1	3½	4	8 3/10
0	16¼	2	0	15	4	11
0	15¼	2	0	24	3	8 2/10
0	28⅙	.	.	.	3	6
0	16⅙	1	1	1½	4	10 3/13
0	26¼	1	1	0	.	.
0	23½	.	.	.	2	11 2/10
.	.	1	0	28½	5	1 6/10
.	.	1	1	10¼	.	.
1	12¼	2	0	14	2	4¼
1	24	2	0	0	.	.
0	3	2	0	0	.	.
1	0	2	0	20	.	.
1	16	.	.	.	.	.
1	10	.	.	.	.	.
1	2	.	.	.	2	10 6/10
0	19	.	.	.	2	0 2/10
0	19½	.	.	.	.	.
0	0	.	.	.	.	.
1	27	.	.	.	.	.
1	0	.	.	.	.	.
1	25½	.	.	.	.	.

Architecture, Naval, the art of constructing ships and vessels to float on the waters. Naval architecture has suffered more than most other sciences by the arbitrary systems of those interested in its improvement. Disregarding the fundamental principles of all floating bodies, and too hastily giving up as hopeless the attainment of a theory combining experiment with established scientific principles, they have contented themselves with ingeniously inventing mechanical methods of forming the designs of ships' bodies, which they did not even pretend to prove had any connexion with the properties of the machine necessary to insure the qualities conducive to its intended use. For instance, some invented methods of forming ships' bodies of arcs of circles; others, of arcs of ellipses, parabolas, or of whatever curve they might arbitrarily assume. They did not attempt to show that these curves possessed any property which would render a ship a faster sailer, a more weatherly or safer ship, than any other curves which might have been adopted in the construction of the ship's body

Architholus, a round chamber, the sudatorium of a Roman bath

Architrave, the lower of the three principal members of the entablature of an order, being the chief beam resting immediately on the column

Architrave cornice, an entablature consisting of an architrave and cornice only, without the interposition of a frieze

Architrave doors, those which have an architrave on the jambs and over the door

Architrave windows, of timber, are usually an ogee raised out of the solid timber, with a roll over it

Archivolt, a collection of members in the face of an arch, concentric with the intrados, and supported by imposts

Archivolt of the arch of a bridge,—the curve line formed by the upper sides of the arch-stones in the face of the work; it is sometimes understood to be the whole set of arch-stones which appear in the face of the work

Archivoltum, a cesspool or common sewer

Archway, an aperture in a building covered with a vault

Arcula, a small coffer or box

Arcus, an area in the form of an ancient basilica:

Arcus, an arch. A true arch is formed of a series of wedge-like stones or of bricks, supporting each other, and all bound together by their mutual pressure

Arcus-toralis, in mediæval architecture, the lattice separating the choir from the nave in a basilica

Ardesia, a slate used in Italy for covering roofs

Area, in geometry, the superficial content of any figure

Areas, in computing the superficial content of land, are generally expressed in statute acres, roods, and perches. The acre is equal to 10 square chains of 66 feet, or 22 yards in length

Arena, the area or floor of an amphitheatre

Arenarium, an amphitheatre, cemetery, crypt, or sepulchre

Areometer, an instrument for measuring the density or gravity of fluids

Areopagus, the court in which the areopagites, or supreme judges of Athens, assembled

Areostylos, intercolumniations, when their distance from each other is four diameters

Arerde, reared, built, or raised up

Argand lamp, a lamp with a circular wick, through which a current of air passes

Argent, in heraldry, in the blazoning of arms, signifies also white or silver

Argyrocopéion, the mint at Athens

Ark, a shelter, a place of protection from floods: in the time of Moses a coffer or sort of bark, in shape and appearance like a chest or trunk; also described by Moses as a little wicker basket in which he was exposed on the Nile. The ancients inform us that the Egyptians used on the Nile barks made of bulrushes. Noah's Ark was, in all probability, in form like these Egyptian boats, but much larger. If we reckon the Hebrew cubit at 21 inches, the ark of Noah was 512 feet long, 87 wide, and 52 high; and the internal capacity of it was 357,600 cubical cubits. If we suppose the cubit to be only 18 inches, its length was 450 feet, its width 75, and its height 45. Its figure was an oblong square; the covering had a declivity to carry off water. Its length exceeded that of most churches in Europe. The wood used for the ark was called gopher-wood, square pieces of wood, cedar or box, or woods that do not easily perish; some supposed it to have been constructed of cyprus wood

Ark: "And this is the fashion which thou shalt make it of; the length of the ark shall be three hundred cubits, the breadth of it fifty cubits, and the height of it thirty cubits." —*Gen.* vi. 15.

Ark (*Noah's*), supposed by some authors to be a mere variation from the customary construction of houses for residence, and to change its character from that of a house for standing, to that of a house for floating. Niebuhr compares it with ordinary houses of the east, that the sides are constructed of upright supports of timber, which are plastered over with clay. The application of canes, split and laid across these quarterings, is very like the usage of laths, which are common every where. The same may be said of the coating of bitumen: the substance was employed on account of its property of resisting water; the mode of its application might be similar to our plastering.

Armarium, a niche or cupboard near the side of an altar

Armiger, in heraldry, an armour-bearer, an esquire

Armilla, an ornament worn by Greek men and women as a bracelet or an armlet

Armour, a defensive clothing of metal

Armoury, a storehouse or room in which armour is preserved

Arnotta (colour), the name of a vegetable substance from the West Indies, of an orange-red colour, soluble in water and spirit of wine, but very fugitive and changeable, and not adapted for painting. It is principally used by the dyer, and in colouring cheese. It is also an ingredient in lacquering

Aronade, embattled, a junction of several lines forming indentations

Arris, in joinery and masonry, the line of concourse, edge, or meeting of two surfaces

Arris fillet, a slight piece of timber of a triangular section, used in raising the slates against chimney shafts, &c.

Arris gutter, a wooden gutter of the V form, fixed to the eaves of a building

Arris-wise, in bricklaying, tiles laid diagonally

Arrondée, in heraldry, the carved cross, the arms which terminate in the escutcheon

Arschin, a Russian measure of length, equal to 2½ feet English

Arsenal, a building for naval or military stores

Arsenic, a white metal of a crystalline appearance, and very brittle. It sublimes out of the air unchanged at 360°, but in air it is oxidated, and becomes arsenious acid; it is occasionally found alone, but is generally combined with nickel, cobalt, and other metals

Artesian wells, so called from a mode practised in Artois in boring for water

Artificer, one who possesses a superior knowledge as an artist or manufacturer

Asarotum, a kind of chequered pavement used by the Romans

Ash, a superior wood of British growth, of a brownish white, with a shade of green; it is tough and elastic, and superior to any other wood exposed to sudden shocks and strains; used for frames of machines, wheel carriages, inside work of furniture, &c.

Ashlar, a term applied to common or free stones as they come out of the quarry. By ashlar is also meant the facing of squared stones on the front of a building: if the work be so smoothed as to take out the marks of the tools by which the stones were first cut, it is called *plane ashlar;* if figured, *tooled ashlar*, or *random tooled*, or chiselled, or bousted, or pointed: if the stones project from the joints, it is said to be *rusticated*

Ashlar, or *Achelor*, hewn stone, used for the facings of walls

Ashlering, in carpentry, the fixing of short upright quarterings between the rafters and the floor

Ash-pan, in locomotive engines, an iron box, open to the front only, attached to the fire-box to receive the ashes from the fire

Asphalt, native bitumen used with pitch as a substitute for pavement

Asphaltum, a bituminous substance, used for pavements and as a building material

Asphaltum, called also Bitumen, Mineral Pitch, &c.; it is a resinous substance rendered brown by the action of the fire, natural or artificial. The substances employed in painting under this name are the residua of the distillation of various resinous and bituminous matters in preparing their essential oils, and are all black and glossy like common pitch, which differs from them only in having been less acted upon by fire, and in their being softer. Asphaltum is principally used in oil-painting; for which purpose it is first dissolved in oil of turpentine, by which it is fitted for glazing and shading. Its

fine brown colour and perfect transparency are lures to its free use with many artists notwithstanding the certain destruction which awaits the work on which it is much employed, owing to its disposition to contract and crack from changes of temperature and the atmosphere

Assay, to examine and prove metals

Assay balance, a very accurate balance, used in determining the exact weights of very small bodies

Assaying, ascertaining the qualities of gold and silver with respect to their purity

Assemblage, in carpentry and joinery, framing, dovetailing, &c.

Assemblage of the Orders in architecture, the placing of columns upon one another in the several ranges

Asseris, small rafters immediately beneath the tiles of a roof

Assurance, or *Insurance*, a contract to make good a loss

Assurance Companies, or *Societies*, afford protection to persons from the chances or hazards to which their property or interests may be exposed.

Assurance on human life is a contract by which a certain amount or capital is secured at the expiration of a stipulated period, either by the payment of a specified sum at the time of *effecting the assurance*, or by the annual payment of a smaller amount, according to the age of a person whose life is assured.

A person, with the view of securing a certain sum of money to his family after his death, desires to effect an assurance, either for a determinate period, as one, three, five, seven, ten, or more years, or for the whole term of his life. In the first case, if the person whose life is assured, die *before* the expiration of the term specified in the policy, his inheritors receive the amount for which the assurance has been effected; but, if the assured live *beyond* that period, they receive nothing, and the assurer reaps the advantage of the contingency. In the latter case,—that is, by assurance for the whole term of life,—the inheritors are entitled to receive the amount named in the policy, upon proof of the death of the person whose life has been assured. To prevent the forfeiture of the policy, it is in all cases essentially important that the conditions upon which it has been granted be strictly complied with.

The calculation as to the amount of premium should be made according to mathematical expectation,—that is, equitably as to both parties, allowing a fair rate of profit to the party granting the assurance. If the terms for assuring £100 be required, for one year, the probability must depend on the age of the person whose life is proposed to be assured; and in equity the sum to be paid should be equal to the value of the expectation, multiplied by the probability of its being obtained. Should the age of the person be 40 years, the probability of death in the course of the year will be, according to the tables of mortality generally adopted, $\frac{671}{38670}$; and this fraction, multiplied by 100, gives the price of the assurance, namely, 1·74 nearly. The result, according to the tables of mortality used in France, is 1·89. This is the rate charged by the 'General Assurance Company' established at Brussels; but the 'Belgic and Strangers' Union Society' charges at the rate of 1·87. Both societies adopt Dubillard's table of of mortality, which is deposited in the Bureau of Longitude in Paris.

The profit to the assurer thus appears to be reduced to the interest on the sum paid by the assured; but persons in health being alone accepted, the chance of profit thereby becomes considerable. For a longer term than one year, the calculations are made on an estimate of the probable amount of interest derivable from the premium paid by the assurer.

Astel, in mining, a board or plank, an arch or ceiling of boards, over the men's heads in a mine, to protect them

Astragal, a small moulding, whose contour is circular, at the neck of the shafts of columns, next the apophyses: it also occurs in the base of Ionic columns, and below the fasciæ of the Corinthian epistylium

Astronomy, a mixed mathematical science, which treats of the heavenly bodies, their motions, periods, eclipses, magnitudes, &c., and of the causes on which they depend: the knowledge of astronomy is essential in navigation and in measuring the earth's surface; the diameter of this, the third planet in the system, is 7924 miles and 7 furlongs

Astylar, a term which expresses the absence of columns or pilasters, where they might otherwise be supposed to occur

Astyllen, in mining, a small ward or stoppage in an adit or mine, to prevent the free and full passage of water, by damming up

Asylum, in the Greek states, the temples, altars, sacred groves, and statues of the gods; a place provided for the protection of debtors and criminals who fled for refuge

Atacamite, prismatoidal green malachite, a native muriate of copper

Athanor, an ancient term for a metal furnaces

Athenæum, a school founded by the Emperor Hadrian at Rome for the promotion of literary and scientific studies

Athwart-hawse, the situation of a ship when driven by the wind or tide across the fore-part of another

Atlantes, in architecture, male figures, used similarly to the female *Caryatides*, in place of columns

Atmosphere, the invisible elastic fluid which surrounds the earth to an unknown exact height, and partakes of all its motions; the constituent parts are—air, water, carbonic acid gas, and unknown bodies. The atmosphere is measured by a column of mercury of 29·922 inches, which has been adopted in France as the mean height of the barometer at the surface of the sea

Atmospheric currents, in high latitudes, when undisturbed, are westerly, particularly in the winter season. If storms and gales revolve by a fixed law, and we are able, by studying these disturbing causes of the usual atmospheric currents, to distinguish revolving gales, it is likely that voyages may be shortened. The indications of a revolving gale are, a descending barometer, and a regularly veering wind

Atmospheric engine, an engine in which the steam is admitted only to the under side of the piston for the up-stroke; it is then condensed, and the top of the cylinder being open, the down-stroke is caused by the pressure of the atmosphere. Marine engines on this principle have three cylinders connected to one crank-shaft, to obtain uniformity of motion

Atmospheric railway. The conclusions drawn by Mr. R. Stephenson are as follows: 1st, That the atmospheric system is not an economical mode of transmitting power, and inferior in this respect both to locomotive engines and stationary engines with ropes. 2ndly, That it is not calculated practically to acquire and maintain higher velocities than are comprised in the present working of locomotive engines. 3rdly, That it would not in the majority of instances produce economy in the original construction of railways, and in many would most materially augment their cost. 4thly, That on some short railways, where the traffic is large, admitting of trains of moderate weight, but requiring high velocities and frequent departures, and where the face of the country is such as to preclude the use of gradients suitable for locomotive engines, the atmospheric system would prove the most eligible. 5thly, That on short lines

of railway, say four or five miles in length, in the vicinity of large towns, where frequent and rapid communication is required between the termini alone, the atmospheric system might be advantageously applied. 6thly, That on short lines, such as the Blackwall Railway, where the traffic is chiefly derived from intermediate points, requiring frequent stoppages between the termini, the atmospheric system is inapplicable, being much inferior to the plan of disconnecting the carriages from a rope, for the accommodation of the intermediate traffic. 7thly, That on long lines of railway, the requisites of a large traffic cannot be attained by so inflexible a system as the atmospheric, in which the efficient operation of the whole depends so completely upon the perfect performance of each individual section of the machinery.

Atmospheric vapour. Deluc proves the amount of force and vapour in a vacuum of any given dimensions is equal to its force and quantity in an equal volume of air at the same temperature, or that the temperature of the air will determine the force and quantity of vapour held in it. M. Le Roi, however, first observed the temperature at which dew commences to be deposited as a rule of ascertaining the moisture of the atmosphere. Dr. Dalton investigated the force of vapour of every temperature, from Zero to the boiling point of water, Fahrenheit, and expressed this force by the weight of the mercurial column it could support in the tube of the barometer. Dalton and Le Roi find the clear point by pouring cold water into a glass, and marking the temperature at which it just ceases to deposit dew on the sides of the glass in the open air. The temperature here observed is the point at which dew would begin to be formed. From this Dalton infers not only the force exerted by the vapour, but also its amount in a perpendicular column of the whole atmosphere, and likewise the force of evaporation at the time of observation

Atramentum, a dye made of soot mixed with burnt resin or pitch, used by the ancients, particularly by painters; and also as a varnish

Atrium, a term applied by the Romans to a particular part of a private house; the court or hall of a Greek or Roman house entered immediately from the fauces of the vestibilium

Attal, Attle, Adall, Addle, in mining, corrupt, impure off-casts in the working of mines

Attic base, the base of a column of upper and lower torus, a scotia, and fillets between them

Attic Order, a low order of architecture, used over a principal order, never with columns, but with antæ or small pilasters

Attics should not be less than one-quarter nor more than one-third of the order they surmount: they are frequently decorated with small short pilasters, whose breadth ought to be equal to the upper diameter of the column underneath them, and their projection usually not more than one-quarter of their breadth

Attic story, the upper story of a house when the ceiling is square with the sides, by which it is distinguished from a common garret

Atticurgus, a term applied by Vitruvius to the base of a column, which he describes as divided by a scotia or trochilus, with a fillet above and below, and beneath all a plinth

Attle, in mining, rubbish, deads, refuse, or stony matter

Attributes, in architecture, symbols given to figures, or disposed as ornaments on a building, to indicate a distinguished character

Attrition, the rubbing of bodies one against another, so as to destroy their surfaces

Auditorium, an apartment in monasteries for the reception of strangers;

also a place where the Roman orators and poets recited their compositions

Auger, a tool for boring large holes; it consists of a wooden handle, terminated at the bottom with steel

Aula, an area or open place; in ancient Roman architecture, a court or hall

Auleolum, a small church or chapel

Aureola, a crown of glory, given by statuaries, &c. to saints, &c. to denote the victory they have obtained

Aurificina, a place for melting and refining gold, &c.

Aurum, anciently, gold

Automaton, an apparently self-acting machine, constructed of weights, levers, pulleys, and springs, by means of which it continues in motion for a definite period

Autometer, an instrument to measure the quantity of moisture

Avenue, a passage from one part of a building to another

Aviary, an apartment or building for the keeping of birds

Avolta, a place vaulted or arched over

A-weather, the situation of the helm of a ship when it is put in the direction from which the wind blows

Awning, a covering of canvass over the deck of a vessel, or over a boat, as shelter from the sun or rain

Axal section, a section through the axis of a body

Axes, the timbers of a roof which form two sides of a triangle, the tignum being the base: more generally termed Principals

Axiom, a self-evident truth

Axis, in architecture, an imaginary line through the centre of a column, &c., or its geometrical representation: where different members are placed over each other, so that the same vertical line, on the elevation, divides them equally, they are said to be on the same axis, although they may be on different planes: thus, triglyphs and modillions are so arranged, that one coincides with the axis or line of axis of each column: in like manner, the windows or other openings in the *several* stories of a façade must all be in the same respective axis, whether they are all of the same breadth or not

Axis, in geometry, the straight line in a plane figure, about which it revolves to produce or generate a solid

Axis, in mechanics: the axis of a balance is the line upon which it moves or turns

Axis, in turning, an imaginary line passing longitudinally through the middle of the body to be turned, from one point to the other of the two cones, by which the work is suspended, or between the back centre and the centre of the collar of the puppet which supports the end of the mandril at the chuck

Axis of a circle or *sphere*, any line drawn through the centre, and terminated at the circumference on both sides

Axis of a cone, the line from the vertex to the centre of the base

Axis of a cylinder, the line from the centre of the one end to that of the other

Axis in peritrochio, a wheel and axle, one of the five mechanical powers, or simple machines; contrived chiefly for the raising of weights to a considerable height, as water from a well, &c.

Axis of rotation, of any solid, the line about which the body really revolves when it is put in motion

Axle bearing, in locomotive engines, the gun-metal, or other metal bearing, under which the axle journal revolves: it is nicely fitted to the journal, and lubricated by a syphon, to reduce, as far as practicable, the friction on the journal

Axle, in locomotive engines, *journal* or *neck*, the part of the axle turned and polished for revolving in the axle-box bearing

Axle, leading, in locomotive engines, the front axle of the engine: eight-wheeled engines have two axles in front of the driving wheel axle, and they are often called leading axles

Axle, trailing, the last axle of the engine, usually placed under the foot-

plate: in Stephenson's and Crampton's patent engines, the driving wheel axle is the last axle

Axles, in locomotive engines, the iron shafts supporting the engine, and on which the wheels are fixed

Axles: driving wheel; in locomotive engines, with inside cylinders, this is a cranked axle; with outside cylinders, it is a straight axle: it is called the driving axle because the connecting-rods and eccentric-rods connect this axle to the pistons, slide-valves, and pumps, and by converting the rectilinear motion of the piston into a rotatory one, it propels or drives the engine in the direction required

Axle-box, in locomotive engines, the box (usually cast iron) fitted up with a metal bearing in it, which rests upon the polished part of the axle

Axle-box cover, in locomotive engines, the plate of iron (usually lined with leather) fitted to the top of the axle-box to keep the oil clean, and also from shaking out by the motion of the engine

Axle-box syphon, in locomotive engines, the small tubes fitted into the top of the axle-box for feeding oil on to the axle journal as it revolves: the oil is fed by a piece of cotton or worsted, having one end introduced into these pipes, and the other end lying down amongst the oil in the axle-box

Axle-guards, or *horn-plates*, in locomotive engines, the parts of the frame in which the axle-box slides up and down, as acted upon by the springs

Axle-guard stays, in locomotive engines, the iron rods bolted to the frame and to all the ends of the axle-guards, to strengthen them

Azimuth compass, an instrument used at sea for finding the sun's magnetic azimuth

Azimuth dial, a dial of which the style or gnomon is perpendicular to the plane of the horizon

Azote, in chemistry, an important constituent of atmospheric air, &c.; also a gas called nitrogen, which, when breathed alone, destroys life

Azure, in heraldry, the blue colour, in the shields of all persons under the rank of baron: in painting, a light or sky-coloured blue

BAB

BABEL, *tower of*, built by the posterity of Noah, after the Flood; remarkable for its great height, and for the disappointment of the builders by the confusion of their language. It was erected in the plain of Shinar, upon the banks of the great river Euphrates, and near the place where the famous city of Babylon subsequently stood. "Let us build us a city and a tower whose top may reach unto heaven."—*Gen.* xi. 4. * * * "The name of it is called Babel, because the Lord did there confound the language of all the earth, and from thence did the Lord scatter them abroad upon the face of all the earth."—*Ib.* xi. 9

Babylonian architecture takes its appellation from the magnificence and *extent of* the public buildings of Babylon. This city was founded by Nimrod about 1665 years before Christ: its walls were 50 cubits thick and 200 in height, built of bricks made from the earth dug out of the ditch that surrounded the city. In the walls were 100 gates made of brass; the jambs and lintels were made of the same metal

Babylonian engine. The engine that raised water from the Euphrates to supply the hanging gardens of Babylon was constructed and used in this the most ancient and splendid city of the early age, founded by the builders of Babel, and enlarged by Nimrod; extended and beautified by Semiramis. This engine greatly exceeded in the perpendicular the the height to which the water was elevated by it. Extensive terraces

were formed one above another to the top of the city walls; and to supply them with the necessary moisture, the engine was erected, of which no account is known at the present time

Bac, in navigation, a praam or ferry-boat

Bac, in brewing, a cooler

Baccalaureus, an ecclesiastical apparitor or verger, who carries a staff of office

Bacca, a light-house, watch-tower, or beacon

Baccharis, a ploughman's spikenard

Back, the back of a lode is the part of it nearest the surface; the back of a level is that part of the lode extending above it to within a short distance of the level above

Back-board, in turning, that part of the lathe which is sustained by the four legs, and which sustains the pillars that support the puppet-bar; the back-board is only used in the best constructed lathes

Back centre screw, the screw for setting up the back centre of a lathe, to the work to be turned, after the puppet-head has been fixed

Backed, a sea phrase, to back an anchor, to carry out a smaller one a-head of the one by which the vessel rides, to take off some of the strain

Back-ground, in painting, is the space of ground behind the principal objects of the picture

Back-links, the links in a parallel motion which connect the air-pump rod to the beam

Back of a hip, in carpentry, is the upper edge of a rafter between two sides of a hipped roof, formed to an angle, so as to range with the rafters on each side of it

Back of a window, the board or wainscoting between the sash-frames and the floor, uniting with the two elbows in the same plane with the shutters: when framed it is commonly with single panels, with mouldings on the framing corresponding with the doors, shutters, &c., in the apartment in which it is fixed

Back-painting, the art of painting mezzotinto prints, on plate or crowned glass with oil colours

Backs, in carpentry, the principal rafters of a roof

Back-staff, an instrument invented by Capt. Davis for a sea quadrant, so named because the back of the observer is turned towards the sun when using it

Back-stays, long ropes from the top-mast heads to both sides of the ship, where they are extended to the channels

Back-stay stool, a short piece of plank fitted for the security of the dead eyes and chains for the back-stays, though sometimes the channels are left long enough at the after end for the back-stays to be fitted thereto

Bac-maker a cooper who makes liquor bacs, &c.

Baculometry, the art of measuring either accessible or inaccessible lines, by the help of baculi, staves, or rods

Badigeon, in statuary, a mixture of plaster and freestone sifted and ground together, used by statuaries to repair defects in their work

Bagnette, a small moulding, like the astragal: when enriched with foliage, it is called a chaplet; when plain, a head

Bagnio, a bath

Bagpipe. To bagpipe the mizen is to lay it aback by bringing the sheet to the weather-mizen rigging

Bailey, an area of ground, a court within the walls of a fortress; in modern acceptation, frequently used as prison

Bakehouse, an apartment with an oven to bake bread

Baker's central rule for the construction of equations; is a method of constructing all equations not exceeding the 4th degree

Bal, a term used in mining

Balance, or equilibrium, in a picture, is when the forms of objects, the lights, shades, colours, and expressions, are happily adapted to each other, and no one figure or colour

overpowers or obscures the rest. When a building is seen in one corner of a picture, it is frequently balanced by something in the other; even a large bird will have the effect

Balance, one of the six simple powers in mechanics, chiefly used in determining the equality or difference in heavy bodies, and consequently their masses or quantities of matter

Balance, in mechanics, are various; the common balance, the bent lever balance, the Roman balance, and the Swedish or Danish balance,—adjustment of differences in weights, &c.

Balance (Hydrostatical), an instrument for determining the specific gravity of bodies

Balance, of a clock or watch, is that part which, by its motion, regulates and determines the beats

Balance gates, in hydraulic engineering, are best described as follows: Balance gates at the Compensation Reservoir of the East London Water Works.—These gates were designed for the purpose of discharging the body of water collected in the reservoir during the rise of the tide, in order to supply the mills lower down the river Lea, which might otherwise have been injured by the amount withdrawn from the river by the pumping-engines of the water company. They differ in construction from common flood-gates, being made to work upon a vertical shaft or spindle, as a centre, and having an equal surface of gate on each side of that centre, so that whatever pressure of water there may be on one side of the gate tending to force it open, there is as great a pressure on the opposite leaf to keep it shut

Balance reef, a reef in a spanker or fore-aft mainsail, which runs from the outer head eaving diagonally to the tack; it is the closest reef, and makes the sail triangular

Balcony, a projection in the front of a house or other building, supported by consoles or columns, sometimes applied to the interiors of theatres, and for public convenience in larger buildings

Balcony, the projecting gallery in the stern of large ships

Baldachin, a canopy supported by columns, and raised over altars, tombs, &c.

Baldachino, in architecture, an open building supported by columns and covered with a canopy, frequently placed over an altar

Bale. To bale a boat, is to throw water out of her

Balistics, used by some for projectiles in the art of throwing heavy bodies

Balistraria, a room in fortified buildings, wherein the crossbows were deposited

Ball, is any spherical body, either natural or artificial

Ballast, for ships, materials for which consist of gravel, iron, or stone, or any heavy substance, to stow away in the hold, to bring a ship to a proper water-line when unladen, and counterbalance the effect of the wind on the masts, and to give stability

Ball-cock, a hollow globe of metal attached to the end of a lever, which turns the stopcock of a cistern-pipe by floating on the surface of the water, thereby regulating the supply

Ball flower, an ornament like a ball, placed in a circular flower, the petals of which form a cap round it, and belongs to the decorated style of the 14th century

Ball of a pendulum, is the weight at the bottom of it, and is sometimes called the bob

Ball and socket, an instrument made of brass with a perpetual screw, so as to move horizontally, vertically or obliquely, and is used for the managing of surveying and astronomical instruments

Ballista, in practical geometry, the same as the geometrical cross, called the Jacob's Staff

Ballistic Pendulum is an instrument

for measuring the velocity of a cannon ball, *i. e.* the force of gunpowder. It consists, in its simplest form, of a beam, which can swing on a fixed axis at one end, while the ball strikes the other end; and the angle through which that end moves being known, the velocity of the cannon ball may be computed

Balloon, a spherical hollow body, floating in the air by means of its inflation with gas specifically lighter than the atmosphere

Balloon, a globe placed on the top of a pillar or pediment, as an acroter or crowning

Balls, in electricity, invented by Mr. Canton, are two pieces of cork or pith of elder-tree, nicely turned in a lathe to the size of a small pea, and suspended by delicate threads

Ball valves, the valves in the force-pumps of a locomotive engine: the balls are turned and ground truly spherical, so as to fit water-tight into the valve-seats in every position

Balneac, in Greek, signifies a bath or bathing vessel

Balteum, a band or girdle, according to Vitruvius: this word is used to denote the moulding on the bolsters or sides of the Ionic capital

Baltei, the bands in the flanks of Ionic pulvinated capitals. Balteum and balteus were generally used by the Romans to signify the belt by which the sword or quiver was suspended

Baluster, a small column or pillar, used in a balustrade

Balusters, placed round the gallery in the stern, and likewise in the quarter gallery of large ships

Balustrade, a series or row of balusters, joined by a rail, serving for a rest to the arms, or as a fence or inclosure to balconies, altars, staircases, &c.

Balustrades, when intended for use, as against windows, on flights of steps, terraces, and the like, should not be more than three feet six inches, nor less than three feet in height. When used for ornament, as on the summit of a building, their height may be from two-thirds to four-fifths of the entablature whereon they are employed: and this proportion is to be taken exclusive of their zoccolo or plinth, so that from the proper point of sight the whole balustrade may be exposed to view. There are various species of balusters; if single-bellied, the best way is to divide the total height of the space allotted for the balustrade into thirteen equal parts,—the height of the baluster to be eight, of the base three, and of the cornice two of those parts; or divide the total height into fourteen parts, making the baluster eight, the base four, and the cornice two. If double-bellied, the height should be divided into fourteen parts, two of which are to be given to the cornice, three to the base, and the remainder to the baluster.

The distance between two balusters should not be more than half the diameter of the baluster in its thickest part, nor less than one-third of it;—but on inclined planes the intervals should not be quite so wide.—*Gwilt.*

Band, in architecture, denotes any flat low member, or moulding, that is broad and not very deep

Banderole, in heraldry, a narrow flag or streamer affixed under the crook of a crosier, and folding over the staff

Bandlet, a small fillet, or flat moulding

Bandrol, a little flag or streamer affixed to the top of masts

Bank, a long piece of timber

Bank. To double bank an oar, is to have it pulled by two men

Banker, in bricklaying, is a bench from 6 to 12 feet in length; is used for preparing the bricks for gauged work

Banker, a cushion or covering for a seat

Banneret, in heraldry, a knight made in the field

Banquet, the raised footway adjoining to the parapet on the sides of a bridge

Baptaterium, a back mill or fulling mill

Baptistery, a place or edifice where baptism is performed. A basin, pool, or place for bathing

Bar, a barrier, gatehouse: in law, a place where counsellors plead

Bar, a bank or shoal at the entrance of a harbour

Bar of ground, in mining, any course of vein which runs across a lode, or different from those in its vicinity

Barberry wood is of small size, resembling alder, and is straight and tenacious

Barbican, in the middle ages, the part of a fortress where watch and ward was kept

Barcella, a vessel containing incense

Barcon, a luggage vessel used in the Mediterranean

Bardiglione, a blue variety of anhydrite, cut and polished for ornamental purposes

Bare poles, the condition of a ship when she has no sail set

Barge, a large double-banked boat used by the commander of a vessel in the navy

Barge board, the front or facing of the former, to conceal the barge couples, laths, tiles, thatch, &c.

Barge boards, or, more properly, *verge boards*, pendants, pinnacles, and brackets, being the chief decorations of houses in early domestic architecture, should always be made of strong oak, and left to acquire by age a grey hue; and not of slight deal, painted, as is now the too frequent practice

Barge couples, in architecture, a beam mortised into another, to strengthen the building

Barge course, a part of the tiling or thatching of a roof, projecting over the gable, and filled up with boards, mortar, &c.

Bar iron, long prismatic pieces of iron, being rectangular parallelopipeds, prepared from pig iron, so as to be malleable for the use of blacksmiths for the method of joining bars

Barium, a metal that exists in the sulphate and carbonate of barytes; found in nature in great abundance

Barker's mill, an hydraulic machine in much use

Barkery, a tan-house; also a sheepcote

Barmkyn, the rampart or outer fortification of a castle

Barn, a covered farm-building for laying up grain, hay, straw, &c.

Barnacle, a shell fish often found on a vessel's bottom

Barometer and Sympiesometer. The barometer is a measure for the weight of the atmosphere, or its pressure on the surface of the globe. It is well known, that it is owing to the atmospheric pressure that water rises in a common pump, after the air has been drawn from the barrel; but that the height to which it can be raised by this means is limited, and not much exceeds 30 feet. A little more than 30 feet of water, therefore, balances the atmosphere. Mercury being about twelve times heavier than water, about 30 inches of mercury will also counterpoise the atmosphere. The principle of the barometer is simple. If a tube, about 3 feet long, closed at one end and open at the other, be filled with mercury, and, with the open end stopped by a finger, this tube be reversed, and placed upright in a cup partly filled with the same liquid, the mercury in the tube, in ordinary states of the weather, will descend to 30 inches, measured from the surface of the fluid in the cup, and not much lower. The mercury is sustained in the tube by the pressure of the atmosphere on the surface of the fluid in the cup. Such a tube and cup, so filled, would in fact be a barometer; and if a moveable index were added to it, this simple instrument would indicate the changes which take place in the

atmospheric pressure. The sympiesometer is a more delicate instrument, for measuring the atmospheric pressure; but it is also a more complicated one than the mercurial barometer, and it would be best understood by inspection. The upper part of the tube contains hydrogen gas, which is elastic; and the lower part, including the well, contains oil. By this compound construction, whilst the length of the tube is less than that of the mercurial barometer, the index, or scale for measuring the pressure, is increased. Hydrogen gas being very sensibly affected by all changes of temperature, the index, by which the atmospheric pressure is read, requires to be set according to the actual temperature, before the atmospheric pressure can be read off.

Since mercury expands by heat, a correction for temperature is also required for the mercurial barometer, when exact calculations are to be made; and for this reason barometers usually have a thermometer attached to them, in order that the temperature may be read off, and recorded at the same time that the barometer is registered.

The following is a table for the correction to be applied to the observed height of the mercury, to reduce it to the freezing point, at 32° Fahrenheit, or zero of the centigrade scale.

Reduction of the English Barometer to the Freezing Point, or to 32° on Fahrenheit's Scale.—*Subtractive.*

Temp.		Part I.—For Mercury only. Height of the Barom. in Inches.				Part II.—Mercury and Brass. Height of the Barom. in Inches.				Diff. to 1 In.
Fah.	Cent.	28 In.	29 In.	30 In.	31 In.	28 In.	29 In.	30 In.	31 In.	
32°	0°·00	0·0000	0·0000	0·0000	0·0000	0·0088	0·0091	0·0094	0·0097	2
34	1·11	0·0056	0·0058	0·0060	0·0062	0·0138	0·0143	0·0148	0·0152	5
36	2·22	0·0112	0·0116	0·0120	0·0124	0·0188	0·0194	0·0201	0·0208	7
38	3·33	0·0168	0·0174	0·0180	0·0186	0·0238	0·0246	0·0255	0·0263	9
40	4·44	0·0224	0·0232	0·0240	0·0248	0·0288	0·0298	0·0309	0·0319	11
42	5·55	0·0280	0·0290	0·0300	0·0310	0·0338	0·0350	0·0362	0·0374	12
44	6·66	0·0336	0·0348	0·0360	0·0372	0·0388	0·0402	0·0416	0·0430	14
46	7·77	0·0392	0·0406	0·0420	0·0434	0·0438	0·0454	0·0470	0·0485	16
48	8·88	0·0448	0·0464	0·0480	0·0496	0·0488	0·0506	0·0523	0·0541	17
50	10·00	0·0504	0·0522	0·0540	0·0558	0·0538	0·0558	0·0577	0·0596	19
52	11·11	0·0559	0·0579	0·0599	0·0619	0·0588	0·0609	0·0630	0·0652	21
54	12·22	0·0615	0·0637	0·0659	0·0681	0·0638	0·0661	0·0684	0·0707	23
56	13·33	0·0671	0·0695	0·0719	0·0743	0·0688	0·0713	0·0738	0·0762	25
58	14·44	0·0727	0·0753	0·0779	0·0805	0·0738	0·0765	0·0791	0·0818	26
60	15·55	0·0783	0·0811	0·0839	0·0867	0·0788	0·0817	0·0845	0·0873	28
62	16·66	0·0838	0·0868	0·0898	0·0928	0·0838	0·0868	0·0898	0·0928	30
64	17·77	0·0894	0·0926	0·0958	0·0990	0·0888	0·0920	0·0951	0·0983	32
66	18·88	0·0950	0·0984	0·1018	0·1051	0·0938	0·0971	0·1005	0·1039	34
68	20·00	0·1005	0·1041	0·1077	0·1113	0·0988	0·1023	0·1058	0·1094	36
70	21·11	0·1061	0·1099	0·1137	0·1175	0·1037	0·1075	0·1112	0·1149	38
72	22·22	0·1117	0·1156	0·1196	0·1236	0·1087	0·1126	0·1165	0·1204	40
74	23·33	0·1172	0·1214	0·1256	0·1298	0·1137	0·1178	0·1218	0·1259	42
76	24·44	0·1228	0·1271	0·1315	0·1359	0·1187	0·1229	0·1272	0·1314	44
78	25·55	0·1283	0·1329	0·1375	0·1421	0·1237	0·1281	0·1325	0·1369	45
80	26·66	0·1339	0·1387	0·1434	0·1482	0·1286	0·1332	0·1378	0·1424	47
82	27·77	0·1394	0·1444	0·1494	0·1544	0·1336	0·1384	0·1432	0·1479	49
84	28·88	0·1450	0·1502	0·1553	0·1605	0·1386	0·1435	0·1485	0·1534	51
86	30·00	0·1505	0·1559	0·1613	0·1667	0·1435	0·1486	0·1538	0·1589	53
88	31·11	0·1561	0·1616	0·1672	0·1728	0·1485	0·1538	0·1501	0·1644	54
90	32·22	0·1617	0·1674	0·1731	0·1790	0·1535	0·1589	0·1644	0·1699	56
P. P. for Temp. F. +		0°. 4 12	0°. 8 24	1°. 2 35	1°. 6 47	2°. 0 59	0°. 4 10	0°. 8 21	1°. 2 31	1°. 6 42	2°. 0 52

From Galbraith's Tables.

The atmosphere is supposed to extend to about the height of 50 miles; and its density to diminish from the surface of the globe upwards, in a geometrical ratio.

Thus, when observations are made on land, above the level of the sea, a correction is required for altitude, since the weight of the atmosphere diminishes as we ascend. It is owing to this that we are enabled to determine the height of mountains by barometers; and that aeronauts compute the altitude to which they ascend in balloons.

If any fluid in a cup be put into rapid circular motion, we should have a representation of the form that portion of the atmosphere assumes which is within the limits of a storm; the most depressed part of the fluid would represent the centre of the gale where the atmospheric pressure is the least.

The principle of the barometer should be explained in all works on navigation, and in all schools where navigation is taught

Baron, in heraldry, a degree of nobility next to a viscount

Baronet, in heraldry, the lowest degree of honour that is hereditary

Baroscope, an instrument for proving the weight of the atmosphere

Barque, a three-masted vessel having her fore and main masts rigged like a ship's, and her mizen-mast like the main-mast of a schooner, with no sail upon it but a spanker

Barra, in the middle ages, a tower or bar at one end of a bridge

Barrack, a building for the lodgment of soldiers

Barraly, in heraldry, the field divided barwise, into several parts, side to side

Barrel, in machinery, is a term applied generally to any thing hollow and cylindrical

Barrow, in mining, a heap of dead attle, rubbish, &c.

Barrows, or tumuli, monuments of the greatest antiquity, raised as sepulchres for the interment of the *great*

Barrulet, in heraldry, the fourtl of the bar, or one-half the cl

Barry, in heraldry, is when an cheon is divided barwise, o any number of compartments

Barry-bendy, in heraldry, is the escutcheon is divided e barwise and bendwise

Barry-pily, in heraldry, is wl coat is divided by several drawn obliquely from side to where they form acute angle

Bars, straight pieces of timb metal that run across from part of a machine to another

Bartisan, in architecture, the overhanging turrets which p from the angles on the top tower, or from the parapet or parts of a building

Bartisan, a wooden tower; a on the top of a house, cast church tower

Barton, a manor-house, or out-

Bar Wood, is an African wood to five feet long. It is used a dip wood, used for violin ramrods, and turning

Barytes, a heavy mineral subst found in copper mines, and merly named 'ponderous spa

Basalt, a variety of trap rock, u of a dark green or brownish colour, composed of augite an spar, with some iron and oliv

Basaltes, a heavy, hard stone, c black or greenish, consisti prismatic crystals, the numb whose sides is uncertain

Basanite, a variety of schistose stone, called also Lydian sto

Base of a figure, in geometry, de the lowest part of its perimet

Base of a conic section, is a line in the parabola and hype formed by the common inters of the cutting plane and the of the cone

Base, in architecture, the lowe or member of a column, on the shaft stands

Base-court, the outer or lower of a castle, appropriated to st offices, &c.

Base-line, in perspective, the common section of a picture and the geometrical plane

Base-line, in surveying, a line, measured with the greatest possible exactness, on which a series of triangles are constructed, in order to determine the position of objects and places. The measurement of degrees of the meridian, for the purpose of ascertaining the size of the earth, have been undertaken in various countries, with extreme accuracy. The arc measured by the French extended from Dunkirk to the southernmost point of the Balearic Islands, including 120°, 22′, 14″, having its centre halfway between the equator and the north pole. Another survey of this kind was performed on a part of the shore of Pennsylvania, which happens to be so straight and level as to admit of a line of more than 100 miles being measured directly without triangulation. Very long lines have also been measured (trigonometrically) by order of the English government, both at home and in India, the mean result of which makes the earth's axis 7898 miles, 5 furlongs, 16 yards, and the diameter of the equator 7924 miles 7 furlongs

Basement, the lower story or floor of a building; the story of a house below the level of the ground

Basements. As an alternative for employing orders upon orders, the ground floor is made to assume the appearance of a basement, and the order that decorates the principal story placed thereupon: in such cases the basements should not be higher than the order it supports, nor lower than one-half the height of the order; but if a basement be introduced merely for the purpose of raising the principal or ground-floor, it may be three, four, five, or six feet high, at pleasure.

These basement stories are generally in rock-worked or plain rustics; and in no case should the height of a rustic course be less than one module of the order resting on the basement, nor should it ever much exceed it: their joints, *if square*, ought not to be broader than one-eighth of the height of the rustic, nor narrower than one-tenth, and their depth should equal their breadth; *if chamfered*, the whole joint may be one-quarter to one-third the height of the rustic, the joint being always right-angled.

When the basement is high, it is sometimes crowned with a cornice, but a platband is more commonly used.—*Gwilt.*

Basenet, a helmet

Base-plate, the foundation plate of an engine

Basil, that angle the edge of a tool is ground to

Basilica, in the time of the Romans, a public hall or court of judicature. After the conversion of the emperor Constantine to Christianity, these edifices were converted into Christian churches The *Basilicæ* of the Romans were the types from which the early Christian places of worship were taken; and the ruins of these buildings were the chief materials used. In several instances the columns that divide the centre part of the church from the aisles have been taken from other edifices, either on account of the want of artists capable of executing any thing equal to them, or the haste with which they were erected. The expedient that was adopted tends to show that proportion was not considered; some columns were reduced from their former height, and others mounted on pedestals to suit the purposes to which they were applied. Besides this total disregard to proportion in the shafts of the columns, capitals and bases were applied without any consideration to their fitness. The heathen basilicæ, generally situated in the forums, were of rectangular form, and divided into three or five parts by rows of columns parallel to the

length of the building; another colonnade at the extremity crossed the former at right angles, and in the middle of the end wall was a semicircular recess, in which was situated the tribune of the judge. These basilicæ had likewise galleries over the aisles, in which commercial or other business was transacted; but in the Christian churches this was appropriated to the women, who (as in the Jewish synagogues) were not allowed to join with the men in the lower parts of the building. These galleries were omitted in the after basilicæ, and one of the aisles was retained solely for their use. Six of the principal churches or basilicæ at Rome are attributed to the zeal of Constantine. The basilicæ of St. John de Lateran, St. Peter, St. Laurentius, St. Paul, St. Agnes, and St. Stephen were built by him, besides the baptisterium that bears his name

Basilicula, a shrine, oratory, or cenotaph

Basins and ewers. In early times, before the cleanly custom of using a fork was practised, the hands were frequently washed during dinner: a basin and ewer were handed for that purpose by an attendant. At the feast given by Henry VIII. to the French ambassadors, there were three ewry boards; one for the king, another for the queen, and the third for the princes, &c.

Basset. The basset or outcrop means the emergence at the surface of the different mineral strata from beneath each other

Bass-relief or *Basso-rilievo*, a species of low sculpture, the figures of which do not stand out from the ground in their full proportion

Bastard stucco, a three-coated plaster, the first generally roughing in or rendering; the second floating, as in trowelled stucco; but the finishing coat contains a little hair besides the sand: it is not hand-floated, and the trowelling is done with less labour than what is called trowelled stucco

Bastard-toothed file, in smithing, that employed after the rubber

Bastard-wheel, a flat bevil-wheel, or one which is a near approach to a spur-wheel

Bastida, in the twelfth century, a place of defence, a fortress

Bastile, a prison; a castle, tower, fortress, or any place of defence

Bastion, a rampart, bulwark, or earthen mound

Batardeau, a coffer-dam, or case of piling without a bottom, for building the piers of a bridge

Batch, in mining, a certain quantity of ore sent to the surface by any pair of men

Bateau, a light boat, long in proportion to its breadth

Bath, a receptacle of water, in which to plunge, wash, or bathe the body. Among the Romans, baths were erected both in magnificence of style and purpose, many of them of great architectural beauty. In later times the bath was always used by the Romans before they went to their supper. The rich generally had hot and cold baths in their own houses; and it was not till the time of Augustus that the baths assumed an air of grandeur and magnificence. The situation chosen for baths ought to be sheltered from the north and north-east. The caldaria and tepidaria should be made to receive their light from the west; or, should local circumstances not admit of this disposition, they may both be made to face the south, because the general time of bathing is from midday until sunset. One thing necessary to be observed is, that the caldaria of that division of the bath which is appropriated to the women should be contiguous to that exclusively used by the men, and have the same aspect; for then the coppers of both may be heated from the same furnace. Three brazen vessels are fixed over the furnace,

which are severally called caldarium, tepidarium, and frigidarium: they are so arranged, that whatever heated water is taken from the first, is replaced by warm water from the second, the deficiency of which is supplied, in a similar manner, from the third. The concave coverings of the small tubes of both baths are likewise heated from the same furnace. The insulated stages of the caldaria are thus constructed: the floor is made inclining towards the furnace, so that if a ball were placed upon any part of it, it would not remain at rest, but take a direction towards the mouth; by which means the flame will more easily pervade the interval between the floors, which is paved with tiles a foot and a half square: upon the floor, earthen props, eight inches each way, are arranged at such intervals as to receive upon them square tiles two feet in length: the props are two feet in height; the tiles which form them are cemented with clay and hair mixed together. The square tiles which they support form the substratum of the pavement of the caldaria

Bath stone, Bath oolite; minute globules, cemented together by yellowish earthy calcareous matter; is much used in building, but not a lasting material. It is soft when quarried, but hardens by exposure to the air

Batifolium, a moveable wooden tower used by besiegers in attacking a fortress

Batten, in carpentry, a scantling of wooden stuff, from two to four inches broad, and about one thick, principally used for wainscot, on which also are bradded, on the plain boards, also batten doors, those which resemble wainscot doors, but are not so; for in wainscot doors the panels are grooved in the framing

Battens, nautical, thin strips of wood put around the hatches to keep the tarpaulin down; also put upon rigging to keep it from chafing. A large batten widened at the end, and put upon rigging, is called a Scotchman

Batter, to displace a portion of the iron of any bar or other piece by the blow of a hammer, so as to flatten or compress it inwardly, and spread it outwardly on all sides around the place of impact

Batter, a term applied to walls built out of the upright, or gently sloping inwards; wharf walls and retaining walls built to support embankments

Batter, the leaning back of the upper part of the face of a wall, so as to make the plumb-line fall within the base

Battery, in electricity, a combination of coated surfaces of glass, commonly jars, so connected together that they may be charged at once and discharged by a common conductor

Battlement, an open or interrupted parapet on the roof of a building; a parapet with embrasures

Baugium, an out-house or domestic office

Baulk, a piece of foreign fir, or deal, from 8 to 16 inches square, being the trunk of a tree of that species of wood; generally brought to a square for the use of building

Bawk, a cross beam in the roof of a house which unites and supports the rafters; a tie-beam

Bay, a division of a roof or vaulting of a building, consisting of the space between the beams or arches. A part of a window between the mullions is often called a bay or day

Bay, in plastering, the space between the skreeds, prepared for regulating and working the floating-rule

Bay of joists, the joisting between two binding joists, or between two girders when binding joists are not used

Bay of roofing, the small rafters and their supporting purlins between two principal rafters

Bay-salt, salt obtained by evaporating

sea-water in shallow ponds by the heat of the sun; is of a dark grey colour, and contains iodine

Bay tree, a native of Italy and Greece; grows to the height of thirty feet, and is an aromatic wood

Bay-window, an oriel window: a window jutting outwards; frequently called bow-window

Bazaar, a market-place

Beacon, a post or buoy placed over a shoal or bank, to warn vessels off: also a signal-mark on land

Beacon, an eminence on which a tower is placed, with a light to denote the approach of danger

Bead, a small globular ornament used in ancient and modern architecture

Bead and Butt work, in carpentry, framing in which the pannels are flush, having beads stuck or run upon the two edges, the grain of the wood being in the direction of them

Bead and quirk, a bead stuck on the edge of a piece of stuff, flush with its surface

Bead-butt and square-work, framing with bead and butt on one side, and square on the other; is used in doors

Bead-house, a dwelling-place for poor religious persons

Bead-plane, is a moulding plane of a semi-cylindric contour, and is generally used in sticking a moulding of the same name on the edge, or on the side close to the arris

Beak, the crooked end of a piece of iron, to hold any thing fast

Beak, a small pendent fillet, forming a channel behind, to prevent water from running down the lower bed of the cornice

Beak-head, a small platform at the forepart of the upper deck in large ships

Beak iron, the conic part of the anvil, with its base attached to the side, and its axis horizontal

Beaking-joint, is the joint formed by the meeting of several heading joints in one continued line, which is sometimes the case in folded floors

Beam, a horizontal piece of iron or timber, used to resist a force or weight, as a tie-beam, where it acts as a string, or chain, by its tension; as a collar-beam, where it acts by compression; as a bressummer, where it resists a transverse insisting weight

Beam, in steam-engine, a large lever turning upon a centre, and forming the medium of communication between the piston-rod and the crank shaft

Beams. Forms of Beams. In the construction of beams, it is necessary that their form should be such that they will be equally strong throughout; or, in other words, that they will offer an equal resistance to fracture in all their parts, and will, therefore, be equally liable to break at one part of their length as at another.

If a beam be fixed at one end and loaded at the other, and the breadth uniform throughout its length, then, that the beam may be equally strong throughout, its form must be that of a parabola.

This form is generally used in the beams of steam-engines; and, in double-acting steam-engines, the beam is strained sometimes from one side, and sometimes from the other; therefore, both the sides should be of the same form.

Mr. Emerson gives the load that may be safely borne by a square inch rod of each of the following:

	lbs. avoird.
Iron rod, an inch square will bear . . .	76,400
Brass	35,600
Hempen rope . . .	19,600
Ivory	15,700
Oak, box, yew, plum-tree	7,850
Elm, ash, beech . .	6,070
Walnut, plum . . .	5,360
Red fir, holly, elder, plane, crab . .	5,000
Cherry, hazel . . .	4,760
Alder, asp, birch, willow	4,290
Lead	430
Freestone	914

He also gives the following practical rule, viz., That a cylinder, the diameter of which is d inches, loaded to one-fourth of its absolute strength, will carry as follows:

	cwt.
Iron	$135 \times d^2$
Good rope	$22 \times d^2$
Oak	$14 \times d^2$
Fir	$9 \times d^2$

Also he says, that a cylindric rod of good clean fir, of an inch circumference, drawn in length, will bear at its extremity 400 lbs.; and a spear of fir, 2 inches diameter, will bear about 7 tons, but not more.

A rod of good iron, of an inch circumference, will bear nearly 3 tons weight.

A good hempen rope, of an inch circumference, will bear 1000 lbs. being at its extremity.

Mr. Barlow gives the following table as a mean derived from his experiments, on the strength of direct cohesion on a square inch of the following:

	lbs.
Box is about	20,000
Ash	17,000
Teak	15,000
Fir	12,000
Beech	11,500
Oak	10,000
Pear	9,800
Mahogany	8,000

TRANSVERSE STRENGTH OF BEAMS, ETC. The transverse strength of rectangular beams, or the resistance which they offer to fracture, is as the breadth and square of the depth: therefore, if two rectangular beams have the same depth, their strengths are to each other as their breadths; but if their breadths are the same, then their strengths are to each other as the squares of their depths.

The transverse strengths of square beams are as the cubes of the breadths or depths. Also, in cylindrical beams, the transverse strengths are as the cubes of the diameters.

Thus, if a beam which is one foot broad and one foot deep support a given weight, then a beam of the same depth, and two feet broad, will support double the weight.

But if a beam be one foot broad and two feet deep, it will support four times as much as a beam one foot broad and one foot deep.

If a beam one foot square, support a given weight, then a beam two feet square will support eight times as much. Also, a cylinder of two inches in diameter will support eight times as much as a cylinder one inch in diameter.

The following table of data is extracted from tables in Barlow's Essay:

Teak	2,462
English oak	1,672
Canadian do.	1,766
Dantzic do.	1,457
Adriatic do.	1,383
Ash	2,026
Beech	1,556
Elm	1,013
Pitch pine	1,632
Red pine	1,341
New England fir	1,102
Riga fir	1,108
Mar Forest fir	1,262
Larch	1,127

Beam-ends. A ship is said to be on her beam-ends when she inclines very much on one side, so that her beams approach to a vertical position

Beam engine, generally a land engine, which has the top of the piston-rod connected to one end of a lever or beam: by a contrivance called a parallel motion, the beam vibrates upon a central axis, and communicates the motion of the piston to the crank by means of a connecting-rod attached to the other end of the beam, and also gives motion to the various parts

Beam-filling, the brickwork, or masonry, brought up from the level of the under to the upper sides of the beams

Beam gudgeons, the bearings on the centre of the beam, or the central pivot upon which it vibrates

Beam of a balance, the horizontal piece of iron from the ends of which the scales are suspended

Beams, in naval architecture, strong thick pieces of timber stretching across the ship from side to side, to support the decks: they are sustained at each end by thick planks in the ship's side, called clamps, upon which they rest

Bearer, any thing used by way of support to another weight

Bearer, in turning, that part of the lathe which supports the puppets

Bearing, the distance that a beam or rafter is suspended in the clear: thus, if a piece of timber rests upon two opposite walls, the span of the void is called the bearing, and not the whole length of the timber

Bearing, that part of a shaft or spindle which is in contact with the supports

Bearing, a word for delineating an antique plaster figure. It is generally said, if the drawing of a figure has not the same bearing or angles of inclination as the original possesses, it is out in all its bearings

Bearing, in heraldry, the figures on a coat of arms; a coat of arms in general

Bearing, the direction of an object from the person looking. In shipping, the bearings of a vessel are the widest part of her below the plank-sheer; that part of her hull which is on the water line when she is at anchor and in her proper trim

Beat away, in mining, to excavate, usually applied to hard ground

Beating, in navigation, the operation of making progress at sea against the wind

Beaufet, a cupboard or niche

Beau ideal, in painting, that beauty which is freed from the deformity and the peculiarity found in nature in all individuals of a species

Beauty, in architecture, consists of *the following* qualities: magnitude and strength, order and h richness and simplicity; C tion, in which the chief re are magnitude and strengt and harmony; Decoration requisites are richness or sin according to the nature of t position

Becalm, to intercept the winc ternate tacks

Becket, a piece of rope plac to confine a spar or anoth a handle made of rope in t of a circle

Beconage, dues levied for the n ance of beacons

Bed of a brick, the horizon faces as disposed in a wall

Bed, a term used in masonry scribe the direction in wh natural strata in stones li also applied to the top and surface of stones when wo building

Bed, in mining, a seam or ho vein of ore

Beds of a stone are the para faces which intersect the fac work in lines parallel to the l

Beds and Bedding. Feathe bolsters, and pillows filk feathers and down, with ma and every other comfort kind, seem to have been known to, and enjoyed by, perior orders of society th turies ago, as they are now. tions are, however, menti having been given in the r Henry VIII. "to examin night the straw of the kin that no daggers might b cealed."

Beds (*trussing*) were beds packed into chests, for tra and, considering the freq movals, these must have b most convenient kind. Ghent seems to have alwa in such beds, as by his wil pears that he demised to all the beds made for hi "called in England trussing and the "best chambers"

Master Fermor and Sir Adrian Foskewe had trussing-beds

Bed-chambers, in Tudor times. The furniture of these apartments, in great houses, was of the same gorgeous character as that in the chief rooms; and the paraphernalia of an ancient dressing-table yielded only, in the splendour and costliness of plate, to the cupboard of the great chamber, or the altar of the chapel. Like the hall, the state bed-chamber had a high place, on which were placed the 'standing bed' and the 'truckle-bed': on the former lay the lord, and on the latter, his attendant

Beddern, a refectory

Bedding-stone, used in bricklaying, a straight piece of marble: its use is to try the rubbed side of the brick; first, to square, to prove whether the surface of the brick be straight; secondly, to fit it upon the leading skew-back, or leading end of the arch

Bed-mouldings. This may be understood as a collective term for all the mouldings beneath the corona or principal projecting member of a cornice, which, without bed-mouldings, would appear too much like a mere shelf

Bed-plate, the foundation plate of a marine or a direct action engine

Bedsteads, in Tudor times. The posts, head-boards, and canopies, or spervers of bedsteads were curiously wrought and carved in oak, walnut, box, and other woods, and variously painted and gilt. Ginger-colour, hatched with gold, was a favourite style, but purple and crimson were also used in their decorations

Beech, a species of timber very much used by artificers; while young, it possesses great toughness, and is of a white colour: the cohesive strength is 12,225 lbs. weight, which will tear asunder a piece of this timber one square inch

Beech wood, common in Buckinghamshire and Sussex as the best; about fifty feet high and thirty inches in diameter; white, brown, and black colour: it is used for piles in wet foundations; is used also, for its uniform texture and closeness, in in-door works, as the frames of machines, bedsteads, and furniture; also for planes, tools, lathe-chucks, keys, cogs of machinery, brushes, handles, &c.

Beef wood, red-coloured wood, generally applied to Botany Bay oak

Beer-drawing machines are contrivances by means of which beer is drawn up from the barrel or cask

Bees, pieces of plank bolted to the outer end of the bowsprit, to score the fore-top mast stays through

Beetle, or *Maul*, a large mallet to knock the corners of framed work, and to set it in its proper position: the handle is about three feet in length

Before the beam, in naval architecture, is an arch of the horizon, comprehended between a line which crosses a ships' length at right angles, and some object at a distance before it; or between the line of the beam, and that point of the compass which she stems

Belay, to make a rope fast by turns round a pin or coil, without hitching or seizing it

Belfry, that part of the tower of a church which contains bells

Bell. The body of a Corinthian or Composite capital, supposing the foliage stripped off, is called the bell; the same is applied also to the early English and other capitals in Gothic architecture which in any degree partake of this form

Bell, a metallic instrument rung in the belfry of a church for the attendance of divine worship, and upon occasions of rejoicing; composed of three parts of copper and one of tin, called bell-metal

Bell-crank, a bent lever, used for changing a vertical into a horizontal motion

Bell-gable, a term applied to the gable of a religious edifice, having a plain or ornamental niche for the reception of one or more bells

Bellows, the instrument for blowing the fire, with an internal cavity so contrived as to be of greater or less capacity by reciprocating motion, and to draw in air at one place while the capacity is upon the increase, and discharge it by another while upon the decrease. The bellows are placed behind the forge, with a pipe, and are worked by means of a lever, called a rocket. Steam machinery is now much used in the generating of wind for blowing the wind or furnace

Bellows, or water-blowing engine, is a machine in which the stream of air is supplied by the flowing of water

Belly, the hollow part of a compass timber, the round part of which is called the back

Belt, in building, a string-course and blocking-course; a course of stones projecting from a wall, either moulded, plain, fluted, or enriched

Belvedere, a turret, lantern, or cupola, raised above the roof of a building. It is sometimes applied in Italy to open galleries or corridors

Bema, an ambo, or reading-desk; a raised structure for the seat or throne of a bishop

Bema, the sanctuary, presbytery; or chancel of a church

Bema, in Greek, the platform from which the orators spoke in the Athenæum

Ben-alive, Cornish mining

Bench, for carpenters and joiners to do their work on, usually 10 or 12 feet in length, and about 2½ feet in width

Bench planes. The jack-plane, the trying-plane, the long-plane, the jointer, and the smoothing-plane, are called bench planes

Bench table, a low stone seat round the interior of the walls of many churches

Bend, in mining, indurated clay, a name given by miners to any indurated argillaceous substance

Bend, the form of the ship from the keel to the top of the side, as the *midship bend, &c.*

Bend, in heraldry, an honoural dinary, formed by lines draw the dexter-corner to the si base

Bends, the strongest part of a v side, to which the beams, kne foot-hooks are bolted

Bending-strakes, are two wrought near the coverings, v all fore and aft, about one i one inch and a half thicke the rest of the deck, and let between the beams and ledge the upper side to be even w rest of the deck

Bending of timber. The proc bending wood to any requirec depends on the property of h its pressure increases the el of the wood

Bendlet, in heraldry, the sixth a shield

Bendy, in heraldry, applied field when divided into par gonally, and varying in met colour

Benefice, a church endowed wit venue for the performance of service

Benetier, a vessel to contain holy a font, or piscina

Ben-heyl, in Cornish mining, ric

Bentick-shrouds, formerly use extending from the futtock to the opposite channels

Benzine, the bi-carburet of hy procured by heating benzoi with lime

Bergmote, a court held on a decide controversies amon ners

Berne machine, for rooting u the invention of Peter Som Berne

Berth, the place where a vess the place in which a man sl

Beryl, a pellucid gum, of a bluis colour, found in the East Peru, &c., used by artists

Betty, in mechanics, an instru break open doors

Bevel, any angle except one of grees

Bevel, in bricklaying, is for d

the soffit-line on the face of the bricks

Bevel, in joinery. One side is said to be bevelled with respect to another, when the angle formed by these two sides is greater or less than a right angle

Bevel gear, in mechanics, denotes a species of wheel-work where the axis or shaft of the leader or driver forms an angle with the axis or shaft of the follower or the driven. In practice it is requisite to have finite and sensible teeth in bevel gear: these are made similarly to those of spur gear, except that in the latter they are parallel, while in bevel gear they diminish in length and thickness in approaching the apex of the cone: the teeth are of any breadth, according to the strength required. Bevel gearing is stronger, works smoother, and has superseded the face-wheel and trundle

Bevelling, in ship-building, the winding of a timber, &c., agreeably to directions given from the mould-loft

Bevel-wheel, a wheel having teeth formed so as to work at an angle either greater or less than half a right angle

Bibbs, in ship-building, pieces of timber bolted to the hounds of a mast, to support the trestle-trees

Bibliotheca, in Greek, the place, apartment or building where books were kept

Bicarbide of hydrogen. This gas is known by the names of light carburetted hydrogen, marsh-gas, fire-damp, and gas of the acetates. It is discharged from fissures in coal in large quantities, and from the bottoms of the pools in which there is vegetable matter

Bice, a blue colour used in painting, prepared from the lapis Armenius

Bice or *Bise*, in painting, a pale blue colour, procured by the reduction of smalt to a fine powder

Bicellum, the dwelling of a tradesman, having under it two vaults, for the reception of merchandise

Bichoca, a turret or watch-tower

Bier-balk, the church road for burials

Bifrons, in sculpture, double-fronted or faced, usually applied to Janus

Bigelf, an arch or chamber

Bigg, to build

Bigger, a builder

Bight, the double part of a rope when it is folded, in contradistinction from the ends

Bilander, a small vessel with two masts, used chiefly in the canals of the Low Countries

Bilboes, large bars or bolts of iron, with shackles sliding on them, used for criminals

Bilection-mouldings, those surrounding the panels, and projecting before the face of a door, gate, &c.

Bilge, that part of the floor of a ship which approaches nearer to an horizontal than to a perpendicular direction

Bilge-pump, the forcing-pump worked by a marine engine, to discharge the bilge-water from the vessel

Bilge-pump rod, the plunger-rod, or rod connecting the piston of the bilge-pump to one of the side-levers

Bill, the point at the extremity of the fluke of an anchor

Billet-moulding, an ornament used in string-courses and the archivolts of windows and doors

Billion, in numbers, the sum of a million of millions

Bills, the ends of compass or knee-timber

Bimedial line, in geometry, the sum of two medials. When medial lines, equal only in power and containing a rational rectangle, are compounded, the whole will be irrational with respect to either of the two: this is called a first bimedial line; but if two medial lines, commensurable only in power, and containing a medial rectangle, be compounded, the whole will be irrational, and is then called a second bimedial line

Binary, in arithmetic, double

Binder, one who undertakes to keep a mine open

Binding-joists, those beams in a floor

which support transversely the bridgings above and the ceiling-joists below

Bindings, the iron wrought round the dead-eyes

Binnacle, a box near the helm, containing the compass

Binocular telescope, one to which both eyes may be applied

Bins, for wine, open subdivisions in a cellar for the reception of bottles

Birch wood, a forest tree common to Europe and North America; an excellent wood for turning, being of light colour, compact, and easily worked

Birds, in heraldry, are emblems of expedition, liberty, &c.

Bird's-eye perspective is of two kinds, angular and parallel: it is used in the drawings of extensive buildings having spacious courts and gardens, as palaces, colleges, asylums, &c. The observer is supposed to be on an eminence, and looking down on the building, as from a steeple or mountain

Bird's-mouth, in carpentry, an interior angle or notch cut in the end of a piece of timber for its reception on the edge of a pole or plate. It signifies also the internal angle of a polygon

Bireme, a vessel with two banks or tiers of oars

Birhomboidal, having a surface of twelve rhombic faces, which, being taken six and six, and prolonged till they intercept each other, would form two different rhombs

Birthing, the working a top side, bulkheads, &c.

Bisection, in geometry, the division of any quantity into two equal parts

Bishops, prelates holding baronies of the King or of the Pope, and exercising ecclesiastical jurisdiction over a certain extent of territory, called their diocese

Bismuth. This metal is found native, crystallized in cakes, which generally contain small quantities of silver; it is also combined with oxygen, arsenic, and sulphur

Bispia, a bishopric or episcopal palace

Bissextile, or leap-year, a year consisting of 366 days, happening once every four years, by the addition of a day in the month of February, to recover the six hours which the sun spends in his course each year, beyond the 365 days usually allowed for it

Bistre, a brown pigment, extracted by watery solution from the soot of wood fires, when it retains a strong pyroligneous scent. It is of a wax-like texture, and of a citrine-brown colour, perfectly durable. It has been much used as a water colour, particularly by the old masters, in tinting drawings and shading sketches, previously to Indian ink coming into general use for such purposes. In oil, it dries with the greatest difficulty

Bisturres, small towers placed at intervals in the walls of a fortress, forming a barbican

Bit, an instrument for boring holes in wood, &c.

Bitter end, that part of the cable which is abaft the bitts

Bitter Nut wood, a native of America, is a large timber wood, measuring 30 inches when squared; plain and soft in the grain, like walnut

Bitts, in ship-building, perpendicular pieces of timber going through the deck, placed to secure any thing to. The cables are fastened to them, if there is no windlass. There are also bitts to secure the windlass, and each side of the heel of the bowsprit

Bitumen, a name for a number of inflammable mineral substances, known under the names of naphtha, mineral tar, mineral pitch, sea-wax, asphalte, elastic bitumen, or mineral caoutchouc, jet, mineral coal, &c.

Bituminous cement, a factitious substance, used for pavements, for roofs, and other useful purposes

Bituminous limestone, a limestone of a lamellar structure

Black, the last and the lowest in the series or scale of descending colours; the opposite extreme from white; the maximum of colour. To be perfect, it must be neutral with respect to colours individually, and absolutely transparent, or destitute of reflective power in regard to light; its use in painting being to represent shade or depth, of which it is the element in a picture and in colours, as white is of light

Black-band iron-stone, discovered by Mr. David Mushet, in 1801, while engaged in the erection of the Calder iron works. Great prejudice was exerted against him by the iron-masters, in presuming to class the wild coals of the country with iron-stones fit and proper for the blast furnace; yet that discovery has elevated Scotland to a considerable rank amongst the iron-making nations of Europe, and produces an annual average income of £16,500 to Sir W. Alexander, Bart.

Black Botany Bay wood is the hardest and most wasteful of all woods: some of the finest, however, if well selected, exceeds all woods for eccentric turning

Black chalk is an indurated black clay, of the texture of white chalk: its principal use is for cutting into the crayons which are employed in sketching and drawing

Black dye. The ingredients of black dye are logwood, Aleppo galls, verdigris, and sulphate of iron, or green vitriol

Black iron, malleable iron, in contradistinction to that which is tinned, called white iron

Black Jack, in mining, blende

Black lead, plumbago, or graphite, is a native carburet of iron, or oxide of carbon, found principally at Borrodale in Cumberland; consumed in large quantities in the formation of crayons and black-lead pencils for writing, sketching, designing, and drawing

Black ochre, a variety of the mineral black, combined with iron and alluvial clay

Black tin, tin ore when dressed, stamped, and washed, ready for melting

Black wadd, one of the ores of manganese, used as a drying ingredient in paints

Blade, in joinery, is expressive of any part of a tool that is broad and thin, as the blade of an axe, of an adze, of a chisel, of a square: the blade of a saw is more frequently called the plate

Blades, the principal rafters or breaks of a roof

Blanc d'argent, or silver white. This is a false appellation for a white lead, called also French white. It is first produced in the form of drops, is exquisitely white, but is of less body than flake white, and has all the properties of the best white leads; but, being liable to the same changes, is unfit for general use as a water colour, though good in oil or varnish

Blast, the air introduced into a furnace

Blasting of stone, from rocks and beds of stone, for the purpose of quarrying and shaping stones to be used for building purposes. The ordinary implements used are the jumper or cutting-tool, the hammer, and scraper. For the process and its effect, see Sir John Burgoyne's Rudimentary Volume on Blasting, &c.

Blast-pipe, the waste steam-pipe of an engine, but more particularly applied to locomotive engines: in the latter it leads from the exhaust passages of the cylinders into the chimney, and is of great use for forming the draught through the fire-tubes, as each jet of steam emitted creates a partial vacuum in the chimney, which is immediately filled by a current of air rushing through the fire-grate

Blazonry, in heraldry, deciphering of coats of arms

Bleaching, an art divided into branches,

bleaching of vegetable and animal substances requiring different processes for whitening them

Blende, in mining, one of the ores of zinc, composed of iron, zinc, sulphur, silex, and water: on being scratched, it emits a phosphoric light

Blending and melting, in colouring or painting, are synonymous terms. They imply the method of laying different tints on buildings, trees, &c., so that they may mingle together while wet, and render it impossible to discover where one colour begins and another ends. A variety of tints of nearly the same tone, employed on the same object and on the same part, gives a richness and mellowness to the effect; while the outline, insensibly melting into the back-ground, and artfully disappearing, binds the objects together, and preserves them in unison

Bleostaning, Mosaic pavement

Block, a lump of wood or stone

Blocks, pieces of wood in which the sheaves or pulleys run, and through which the ropes pass

Block cornices and entablatures are frequently used to finish plain buildings, where none of the regular orders have been employed. Of this kind there is a very beautiful one composed by Vignola, much used in Italy, and employed by Sir Christopher Wren to finish the second design of St. Paul's cathedral

Block-house, a building erected by besiegers for the investment of a castle. Block-houses were erected in the time of Henry VIII. on the south and south-western coast of England

Blocking-course, a course of masonry or brick-work, laid on the top of a cornice crowning a wall

Blockings, small pieces of wood, fitted in, or glued, or fixed to the interior angle of two boards or other pieces, in order to give strength to the joint

Block-machinery, the machinery for manufacturing ships' blocks, invented by the elder Brunel, and adjusted by the late Dr. Gregory

Block-tin, tin cast into blocks or ingots

Blood-red heat, the degree of heat which is only necessary to reduce the protuberances on coarse iron by the hammer, in order to prepare it for the file, the iron being previously brought to its shape. This heat is also used in punching small pieces of iron

Bloom, a mass of iron after having undergone the first hammering

Blower, in mining, a smelter

Blowing, the projection of air into a furnace, in a strong and rapid current, for the purpose of increasing combustion

Blow-off cock, the stop-cock in the blow-off pipe

Blow-off pipe, the pipe fixed to the bottom of a boiler, for discharging the sediment, which is effected by blowing through a portion of the water from the boiler

Blow-pipe. The blow-pipe is a most valuable little instrument to the mineralogist, as its effects are striking, rapid, well characterized, and pass immediately under the eye of the operator. The most efficacious flame is produced by a regular, moderate stream of air; while the act of blowing with more force only has the effect of fatiguing the muscles of the cheeks, oppressing the chest, and at the same time renders the flame unsteady.

The student should fill his mouth with air, so as to inflate the cheeks moderately, and continue to breathe without letting the air in the mouth escape; the blow-pipe may then be introduced between the lips, and while the breathing is carried on through the medium of the nose, the cheeks will expel a stream of air through the blow-pipe; and by replenishing the mouth at each expiration, and merely discharging the *surplus* air through the nostrils, a facility will be acquired of keeping up a constant stream of air.

The best flame for the purpose of this instrument is that of a thick wax candle, such as are made for the lamps of carriages, the wick being snuffed to such a length as to occasion a strong combustion: it should be deflected a little to one side, and the current of air directed along its surface towards the point: a well-defined cone will be produced, consisting of an external yellow, and an internal blue flame. At the point of the former, calcination, the oxidation of metals, roasting of ores to expel the sulphur and other volatile ingredients, may be accomplished; and by the extreme point of the latter (which affords the most intense heat) fusion, the deoxidation of metals, and all those operations which require the highest temperature, will be effected. The piece of mineral to be examined must necessarily be supported on some substance; and for the earths, or any subject not being metallic, or requiring the operation of a flux, a spoon or pair of forceps made of platina will be found useful; but, as the metals and most of the fluxes act on platina, the most serviceable support, for general purposes, will be a piece of sound, well-burnt charcoal, with the bark scraped off, as free as possible from knots or cracks: the piece of mineral to be examined should not in general be larger than a pepper-corn, which should be placed in a hollow made in the charcoal; and the first impression of the heat should be very gentle, as the sudden application of a high temperature is extremely liable to destroy those effects which it is most material to observe. Many substances decrepitate immediately they become hot; and when that is found to be the case, they should be heated red, under circumstances which will prevent their escape: this may be effected, with the earthy minerals, by wrapping them in a piece of platina foil, and, with the metallic ores, by confining them between two pieces of charcoal, driving the point of the flame through a small groove towards the place where the mineral is fixed, by which means a sort of reverberating furnace may be formed. The principal phenomena to be noticed are, phosphorescence, ebullition, intumescence, the exhalation of vapours having the odour either of sulphur or garlic (the latter arising from the presence of arsenic), decrepitation, fusibility; and, amongst the fusible minerals, whether the produce is a transparent glass, an opaque enamel, or a bead of metal.

Having first made some observations on a particle of the mineral alone, either the residue or a fresh piece should be examined with the addition of a flux, more particularly in the case of the ores, as the nature of the metal may be generally decided by the colour with which it tinges the substance used. The most eligible flux is glass of borax: a piece about half the size of a pea being placed on the charcoal, is to be heated till it melts; the particle of ore being then taken in a pair of forceps, is to be pressed down in it, and the heat applied; or, should the mineral not be inclined to decrepitate, it may be laid on the charcoal, and two or three pieces of glass of borax, about the size of a pin's head, placed over it; and on using the blow-pipe, the whole will form itself into a globular bead.

Blow-valve, the 'snifting valve' of a condensing engine

Blue, one of the seven primitive colours of the rays of light, into which they are divided when refracted through a glass prism

Blue-black is a well-burnt and lavigated charcoal, of a cool, neutral colour, and not differing from the common Frankfort black. Blue-black was formerly much employed in painting, &c.

Blue carmine is a blue oxide of molybdena, of which little is known

as a substance or as a pigment. It is said to be of a beautiful blue colour, and durable in a strong light, but is subject to be changed in hue by other substances, and blackened by foul air: we may conjecture, therefore, that it is not of much value in painting

Blue dyes, indigo, Prussian blue, logwood, bilberry, &c.

Blueing, the process of heating iron, and some other metals, until they assume a blue colour

Blue John, fluor spar, called so by Derbyshire miners

Blue ochre is a mineral colour of rare occurrence, found with iron pyrites in Cornwall, and also in North America, and is a subphosphate of iron. What Indian red is to the colour red, and the Oxford ochre to yellow, this is to other blue colours. They class in likeness of character: hence it is admirable rather for the modesty and solidity, than for the brilliancy of its colour

Blue pigments, found in common, are Prussian blue, mountain blue, Bremen blue, iron blue, cobalt blue, smalt, charcoal blue, ultramarine, indigo, litmus, and blue cake

Blue tint, in colouring, is made of ultramarine and white, mixed to a lightish azure. It is a pleasant working colour, and with it should be blended the gradations in a picture. It follows the yellows, and with them it makes the greens; and with the red it produces the purples. No colour is so proper for blending down or softening the lights into keeping. In pictures of less value, Antwerp blue may be substituted for ultramarine

Blue verditer is a blue oxide of copper, or precipitate of the nitrate of copper by lime, and is of a beautiful light-blue colour. It is little affected by light; but time, damp, and impure air turn it green, and ultimately blacken it, — changes which ensue even more rapidly in oil than in water: it is, therefore, by no means an eligible pigment in oil, and is principally confined to distemper, painting, and the uses of the paper-stainer, though it has been found to stand well, many years, in water-colour drawings and in crayon paintings, when preserved dry.

Blue vitriol, sulphate of copper

Bluff: a bluff-bowed or bluff-headed vessel is one which is full and square forward

Blunk, heavy cotton cloth: the term used in Scotland

Board, a substance of wood contained between two parallel planes; as when the baulk is divided into several pieces by the pit-saw, the pieces are called boards

Board, in nautical language, the line over which a ship runs between tack and tack. *To board* is to enter a ship

Boarding-floors are those covered with boards: the operation of boarding floors should commence as soon as the windows are in, and the plaster dry

Boarding-joists, joists in naked flooring, to which the boards are fixed

Boarding-pike, a pike used by sailors in boarding an enemy's vessel

Boasting, in masonry, the paring of a stone with a broad chisel and mallet

Boasting, in sculpture or carving, is the rough cutting of a stone to form the outline of a statue or ornament

Boats, small open vessels, impelled on the water by rowing or sailing, having different uses, dimensions, &c., either for river or sea service

Boat-hook, an iron hook with a sharp point, fixed on a pole, at the extremity

Boatswain, a warrant officer in the navy, who has the charge of the rigging, and calls the crew to duty

Bob, the miner's engine-beam

Bob, of a pendulum, is the metallic weight which is attached to the lower extremity of a pendulum rod

Bobstay-holes, those in the fore-part of the knee of the head, for the security of the bobstay

Bob-stays, used to confine the bowsprit down to the stem or the cutwater

Bocatorium, anciently a slaughterhouse

Bodium, a crypt, or subterraneous chapel

Body, in physics or natural philosophy, any solid or extended palpable substance

Body, or solid, in geometry, has three dimensions; length, breadth, and thickness. Bodies are either hard, soft, or elastic

Body plan, in naval architectural drawing, sectional parts showing fore and after parts of a vessel

Boeria, anciently a manor-house or large country dwelling

Bog, soft, marshy, and spongy matter, or quagmire. Railroads have been made across bogs in Lancashire and in America by draining, &c., and in the latter by piling as well as draining

Bog-iron ore, an iron ore discoverable in boggy land

Boiler, a wrought iron vessel containing water, to which heat is applied for the generation of steam. Boilers are made of various forms, according to the nature of their application, and are constructed so as to obtain the largest heating surface with the least cubical content

Boilers. A boiler for 20-horse power is usually 15 feet long and 6 feet wide; therefore 90 feet of surface, or 4½ feet to 1 horse power; a boiler for a 14-horse power 60 feet of surface, or 4·3 feet to 1 horse power; but engineers allow 5 feet of surface to 1 horse power, and Mr. Hicks, of Bolton, proportions his boilers at the rate of 5½ square feet of horizontal surface of water to each horse power: Mr. Watt allows 25 cubic feet of space to each horse power

Boilers. Iron cement is far preferable to any other material for making iron joints: it has the excellent property, that it becomes more sound and tight the longer it stands, so that cemented joints which at first may be a little leaky, soon become perfectly tight. The following is the best mode of preparing this iron cement: take 16 parts of iron filings, free from rust; 3 parts powdered sal-ammoniac [muriate of ammonia]; and 2 parts of flower of sulphur: mix all together intimately, and preserve the compound in a stoppered vessel, kept in a dry place, until it is wanted for use. Then take 1 part of the mixture, add it to 12 parts of clean iron filings, and mix this new compound with so much water as will bring it to the consistence of a paste, having previously added to the water a few drops of sulphuric acid. Instead of filings of hammered iron, filings, turnings, or borings of cast iron may be used; but it must be remarked, that a cement made entirely of cast iron is not so tenacious and firm as if of wrought iron; it sooner crumbles and breaks away. It is better to add a certain quantity, at least one-third, of the latter to the former.

There is but little ground to fear for the soundness of a well-riveted iron boiler; for in time the action of rust and deposit will stop almost any crevices. In order, however, to take all precaution, it is to be recommended that some clammy substance, such as horse-dung, bran, coarse meal, or potatoes, should be boiled in the vessel before it is used. A very small quantity also of the same kind of substance may be put into the boiler when first set to work: this will find its way into the crevices by the pressure within, and, gradually hardening, will soon render the vessel perfectly sound.

Boilers. Copper is more tough and less liable to crack than iron, and is a most excellent material for high-pressure boilers: it has, however, a less cohesive power; and therefore a greater thickness of metal is necessary to produce an equal strength: but since copper boilers never fly in pieces in case of explo-

sion, it is not necessary to be too scrupulous in regard to this point. Even when the metal is thin, especially if the diameter is not great, the use of copper removes all danger of destructive explosion, since at most only a simple tearing asunder of the metal will ensue

Boiling, or ebullition, the agitation of fluids, arising from the action of fire, &c.

Bole, an argillaceous mineral, having a conchoidal fracture, an internal lustre, and a shining streak

Bollards, large posts set in the ground at each side of the docks, to lash and secure hawsers for docking and undocking ships

Bollard timbers, in a ship, two timbers within the stern, one on each side of the bowsprit, to secure its end

Bolognes School, in painting, a Lombard school, founded by Caracci

Bolognian stone is derived from sulphate of baryta by calcination and sure to the rays of the sun

Bolster, a piece of timber placed upon the upper or lower cheek, worked up about half the depth of the hawse-holes, and cut away for the easement of the cable, and to prevent its rubbing the cheek; likewise the solid piece of timber that is bolted to the ship's side, on which the stantients for the linings of the anchors are placed; or any other small piece fixed under the gunwale, to prevent the main sheet from being rubbed, &c.

Bolster, a tool used for punching holes and for making bolts

Bolster of a capital; the flank of the Ionic capital

Bolt, a cylindrical pin of iron or other metal, used for various purposes of fastening, planking, &c.

Bolt auger, an auger of a larger size, used by ship-builders

Bolt rope, the rope to which the edges of sails are sewed, to strengthen them

Bolt-screwing machine, a machine for screwing bolts, by fixing the bolt-head to a revolving chuck, and causing the end which it is required to screw to enter a set of dies, which advance as the bolt revolves

Bolts, long cylindrical bars of iron or copper, used to secure or unite the different parts of a vessel

Bolts, the principal iron-work for fastening and securing the ship

Bolts, large iron pins

Bomb-vessel, a strong-built vessel carrying heavy metal for bombardment

Bond, in masonry, is that connection of lapping the stones upon one another in the carrying up of the work so as to form an inseparable mass of building

Bond, in bricklaying and masonry, is the arrangement or placing of bricks, &c., so as to form a secure mass of building

Bonders, Bond stones, Binding stones, stones which reach a considerable distance into, or entirely through, a wall, for the purpose of binding it together

Bond stones, are placed in the thickness of a wall, at right angles to its face, to bind securely together

Bond timber, pieces of timber used to bind in brick-work especially. The naked flooring being laid, in carrying up the second story bond timbers must be introduced opposite to all horizontal mouldings, as bases and surfaces. It is also customary to put a row of bond timber in the middle of the story, of greater strength than those for the bases and surfaces

Bone-brown and *Ivory-brown*, produced by torrefying or roasting bone and ivory, till, by partial charring, they become of a brown colour throughout

Boning, in carpentry and masonry, the art of making a plane surface by the guidance of the eye: joiners try up their work by boning with two straight-edges, which determine whether it be in or out of winding, that is to say, whether the surface be twisted or a plane

Bonnet, in navigation, an additional

piece of canvas attached to the foot of a jib, or a schooner's foresail, by lacings, taken off in bad weather

Bonnets, the cast-iron plates which cover the openings in the valve-chambers of a pump: the openings are made so that ready access can be had when the valves need repairing

Boom, in ship-building, a long pole run out from different places in the ship, to extend the bottoms of particular sails, as jib-boom, flying-boom, studding-sails-boom, &c.

Boomkin, in ship-building, a beam of timber projecting from each bow of a ship, to extend the clue or lower corner of the foresail to windward

Booth, a stall or standing in a fair or market

Boot-topping, scraping off the grease, or other matter, which may be on a vessel's bottom, and daubing it over with tallow

Borax, in chemistry, a salt in appearance like crystals of alum; an artificial salt used for soldering metals

Borcer, an instrument of iron, steel-pointed, to bore holes in large rocks, in order to blow them up with gunpowder

Bord, anciently a cottage

Bore, in hydrography, a sudden and abrupt influx of the tide into a river or narrow strait

Boreas, the north wind

Borer, a boring instrument, with a piece of steel at the end, called a boring-bolt

Boring, the art of perforating or making a hole through any solid body; as boring the earth for water; boring water-pipes, either wood, iron, zinc, or lead; boring cannon, &c.

Boring. Modern steam engines depend on the improved method of boring their cylinders. The cylinder to be bored is firmly fixed with its axis parallel to the direction in which the borer is to move: the cutting apparatus moves along a bar of iron accurately turned to a cylindrical form

Boring-bar, a bar of a small horizontal boring machine: it is used for boring the brasses of plummer-blocks, by means of a cutter fixed in it

Boring-collar, in turning, a machine having a plate with conical holes of different diameters: the plate is moveable upon a centre, which is equidistant from the centres or axes of the conical holes; the axes are placed in the circumference of a circle. The use of the boring-collar is to support the end of a long body that is to be turned hollow, and which would otherwise be too long to be supported by a chuck

Boring lathe, a lathe used for boring wheels or short cylinders. The wheel or cylinder is fixed on a large chuck, screwed to the mandril of a lathe

Boring machine, a machine for turning the inside of a cylinder

Boron, in chemistry, is an olive-green powder, which, heated out of the air, becomes harder, and darker in colour: it burns brilliantly when heated in air or oxygen, forming boracic acid

Boss, a sculptured keystone or carved piece of wood, or moulded plaster, placed at intervals of ribs or groins in vaulted and flat roofs of Gothic structures

Boss, a short trough for holding mortar when tiling a roof: it is hung to the laths

Bossage, projecting stones laid rough in building, to be afterwards cut into mouldings or ornaments

Botany Bay oak, resembling in colour full red mahogany, is used as veneer for the backs of brushes, turnery, &c.

Bottle-glass, a composition of sand and lime, clay, and alkaline ashes of any kind

Bottom-captain, a superintendent over the miners in the bottoms

Bottom heat, artificial temperature, produced in hot-houses

Bottom-lift, in mining, the deepest or bottom tier of pumps

Bottom-rail, in joinery, the lowest rail of a door

Bottoms, in mining, the deepest work-

ing parts of a mine, wrought either by sloping, driving, or otherwise breaking the lode

Bottoms in fork. In Cornwall, when all the bottoms are unwatered, they say, 'the bottoms are in fork;' and to draw out the water from them, or any dippa, or any other particular part of a mine, is said to be 'forking the water;' and when accomplished, such dippa, &c., is 'in fork.' Likewise when an engine has drawn out all the water, they say, 'the engine is in fork'

Bottony; in heraldry, a cross-bottony is terminated at each end in three buds, or knots, or buttons

Boudoir, a small retiring-room

Bouget, in heraldry, the representation of a vessel for carrying water

Boulders, fragments of rocks transported by water, and found on the sea-shore

Boulder walls, walls built of the above

Boultine, in architecture, a convex moulding whose periphery is a quarter of a circle, next below the plinth in the Doric and Tuscan orders

Bounds, in mining, signifies the right to tin ore over a given district

Bourse, a public edifice for the assemblage of merchants to consult on matters of business or money

Boutant; in architecture, an arc-boutant is an arch, or buttress, serving to sustain a vault, and which is itself sustained by some strong wall or massive pile

Bova, anciently a wine-cellar

Bovey coal, wood-coal found at Bovey, in Devonshire

Bow, the round part of the ship forward

Bow, anciently an arch or gateway

Bow compass, for drawing arches of very large aisles; it consists of a beam of wood or brass with three long screws that bend a lath of wood or steel to any arch. The term also denotes small compasses employed in describing arcs too small to be accurately drawn by the common compasses

Bower, anciently a small enriched chamber for ladies; a private room, or parlour, in ancient castles and mansions

Bower, a working anchor, the cable of which is bent and veered through the hawse-hole

Bower, in navigation, two anchors thus named from their being carried at the bow

Bower cables, for ships.

Table showing the different kinds of best bower cables at present employed in the British navy, with the corresponding iron cables, and the proof-strain for each:

Rates of Ships.	Best bower hempen cables, 100 fathoms. Circum.	Weight.	Number of threads in each.	Breaking strain by experiment.	Diameter and weight of the bolt of the iron cable substituted for the preceding.	Strain for the proof.
	in.	cwt. qr. lb.		tons. cwt. qr.		tons.
First-rate, large	25	114 2 7	3240	..	2½ inches. 218 cwt.	81
middle	24	105 2 17	2988	..		
small	23	96 2 27	2736	114 0 0		
Second-rate	23	96 2 27	2736			
Third, large	23	96 2 27	2736			
small	22	89 0 12	2520	89 0 0	2 inches. 186 cwt. 2 qrs.	72
Fourth, 60 guns	21	80 0 22	2268			
58 do.	19	66 0 21	1872	..	1⅞ inch. 170 cwt. 2 qrs.	63
50 do.	18½	62 1 14	1764	..		
Fifth, 48 do.	18	58 2 6	1656	63 0 0	1¾ inch. 145 cwt. 3 qrs.	55
46 do. / 42 do.	17½	56 0 1	1584	..		
Sixth, 28 do.	14½	38 0 21	1080	40 0 0	1⅜ inch. 87 cwt. 2 qrs.	34
Ship, sloop	13½	33 0 10	936	..	1¼ inch. 74 cwt. 3 qrs.	28
Brig, large	13½	33 0 10	936	..		
Ditto, small	11	21 2 15	612	..	1⅛ inch. 61 cwt. 1 qr.	23

From the preceding Table the immense advantage of iron cables will be distinctly seen, and particularly when it is considered that a hempen cable, on a rocky bottom, is destroyed in a few months, while the other will sustain no perceptible injury.

Boweric, in the East Indies, a well descended by steps

Bow-grace, a frame of old rope, or junk, placed round the bows and sides of a vessel, to prevent the ice from injuring her

Bow-line, in navigation, a rope leading forward from the leach of a square sail, to keep the leach well out, when sailing close-hauled

Bowls of silver were used as drinking-glasses are now, before the introduction of glass for such purposes; they were of small sizes, in 'nests' fitting one within another. Of the larger sized bowl, the most distinguished are the mazer and the wassail. Mazer is a term applied to large goblets, of every kind of material; but the best authors agree that its derivation is from *maeser*, which, in Dutch, means maple; and therefore that a mazer bowl is one formed of maple wood

Bow-saw, a saw used for cutting the thin edges of wood into curves

Bowse, to pull upon a tackle

Bowsprit, in ship-building, a large boom or mast which projects forward over the stem to carry sail

Bowtel, the shaft of a clustered pillar, or a shaft attached to the jambs of a door or window

Box, for mitring, a trough for cutting mitres: it has three sides, and is open at the ends, with cuts in the vertical sides at angles of 45° with them

Box-drain, an underground drain built of brick and stone, and of a rectangular section

Box of a rib-saw, two thin iron plates fixed to a handle, in one of which plates an opening is made for the reception of a wedge, by which it is fixed to the saw

Box-haul, to veer a ship in a manner when it is impossible to tack

Box the compass, to repeat thirty-two points of the compass in order

Boxing-off, throwing the head sails a-back, to force the ship's head rapidly off the wind

Boxings of a window, the cases opposite each other on each side of a window, into which the shutters are folded

Box wood is of a yellow colour, inclining to orange; is a sound and useful wood, measuring from 2 to 6 feet long, and 2½ to 12 inches in diameter: it is much used by wood engravers; for clarionets, flutes; for carpenters' rules, drawing-scales, &c. Much of it comes from Box Hill, in Surrey, and from several districts in Gloucestershire, also from other parts of Europe

Boziga, anciently a house or dwelling

Brace, a piece of slanting timber, used in truss partitions, or in framed roofs, in order to form a triangle, and thereby rendering the frame immoveable: when a brace is used by way of support to a rafter, it is called a strut: braces in partitions and span roofs are always, or should be, disposed in pairs, and placed in opposite directions

Brace, an instrument into which a vernier is fixed; also part of the press-drill

Brace, a rope by which a yard is turned about

Braces, that security for the rudder which is fixed to the stern-post and to the bottom of a ship

Bracket plummer-block, a support for a shaft to revolve in, formed so that it can be fixed vertically to the frame of a machine, or to a wall

Brackets, ornaments: the hair bracket in ship-building is the boundary of the aft-part of the figure of the head, the lower part of which ends with the fore-part of the upper cheek. The console bracket is a light piece of ornament at the fore-part of the quarter-gallery, sometimes called a canting-hose

Brackets, the cheeks of the carriage of a mortar; a cramping-iron to stay timber-work; also stays set under a shelf, to support it

Bracket-stairs. "The same method must be observed, with regard to taking the dimensions and laying down the plan and section, as in dogling-stairs. In all stairs whatever, after having ascertained the number of steps, take a rod the height of the story, from the surface of the lower floor to the surface of the upper floor; divide the rod into as many equal parts as there are to be risers; then, if you have a level surface to work upon below the stairs, try each one of the risers as you go on: this will prevent any defect."

Brad, a small nail with a projecting head on one edge

Brad-awl, the smallest boring tool used by a carpenter; its handle is the frustrum of a cone tapering downwards; the steel part is also conical, but tapering upwards, and the cutting edge is the meeting of two basils, ground equally from each side

Brails, in navigation, ropes by which the foot or lower corners of fore and aft sails are hauled up

Brake, the apparatus used for retarding the motion of a wheel by friction upon its periphery

Brake, the handle of a ship's pump

Brake, a machine used in dressing flax

Brake-wheel, the wheel acted upon by a brake

Bramah's hydrostatic press consists in the application of water to engines, so as to cause them to act with immense force; in others, to communicate the motion and powers of one part of a machine to some other part of the same machine

This press was constructed in Woolwich dockyard for testing iron cables, and the strain is produced by hydrostatic pressure: its amount is estimated by a system of levers balanced on knife edges, which act quite independently of the strain upon the machine, and exhibit sensibly a change of pressure of $\frac{1}{8}$th of a ton, even when the total strain amounts to 100 tons.

This proving machine was constructed by Messrs. Bramah, of Pimlico, and is doubtless one of the most perfect of the kind which has been executed. It consists of two cast-iron sides, cast in lengths of $9\frac{1}{2}$ feet each, with proper flanches for abutting against each other, and for fixing the whole to sleepers resting on a secure stone foundation. The whole length of the frame is $104\frac{1}{2}$ feet, equal to $\frac{1}{8}$th the length of a cable for a first-rate; so that the cables are tested in that number of detached lengths, which are afterwards united by shackle-bolts. The press is securely bolted down at one end of the frame, and the cylinder is open at both ends. The solid piston is $5\frac{1}{4}$ inches in diameter in front and $10\frac{1}{2}$ inches behind, so that the surface of pressure is the difference of the two, viz.

$$\left(\overline{\frac{21}{2}}^2 - \overline{\frac{21}{4}}^2\right) \times \cdot 7854 = 65\tfrac{1}{2} \text{ inches.}$$

The system of levers hung on knife edges is attached to the other end of the frame, and the cable is attached by bolt-links to this and to the end of the piston-rod. The levers being properly balanced, and the cable attached to a short arm rising above the axis, this draws the other arm downwards; and at a distance equal to twelve times the short arm, is a descending pin and ball, acting in a cup placed on the upper part of the arm of the second lever, and this again acts on a third. The first two levers are under the floor, and pass ultimately into an adjacent room, where a scale carrying weights is conveniently placed, and the whole combination is such that every pound in the scale is the measure of a ton strain: the whole acts with such precision that $\frac{1}{8}$th of a pound, more or less, in the scale, very sensibly

affects the balance. At the same place is situated a scale, acted upon by the water pressure from the charge-pipe of the press, and the valve in this pipe is of such dimensions that, together with the lever by which it acts, the power is again such that a pound should balance a ton; but the friction is here so great that it requires several pounds to make a sensible change in the apparent balance, and for this reason this scale is never used. The forcing-pumps are in another adjacent room, and are worked by handles, after the manner of a fire engine. At first, six pistons are acting, and the operation proceeds quickly; but as the pressure and strains increase, the barrels are successively shut off, till at length the whole power of the men is employed on one pair of pumps only, and on this the action is continued till the proof-strain is brought on the cable. A communication is then opened between the cistern and cylinder, and everything is again restored to equilibrium.

Branch, in mining, a leader, string, or rib of ore, that runs in a lode; or if a lode is divided into several strings, they are called branches, whether they contain ore or not: likewise strings of ore which run transversely into the lode are called branches; and so are all veins that are small, dead or alive, *i. e.* whether they contain ore or not

Branched-work, carved and sculptured leaves and branches in monuments and friezes

Branches, anciently the ribs of groined ceilings

Brandishing or *Brattishing*, a term used for carved work, as a crest, battlement, or other parapet

Brandrith, a fence or rail round the opening of a well

Brass, a factitious metal, made of copper and zinc

Brass, in the middle ages, a plate of metal inserted or affixed to a flat gravestone

Brasses, sepulchral, monumental plates of brass or mixed metal, anciently called *latten*, inlaid on large slabs of stone, which usually form part of the pavement of a church, and represent in their outline, or by lines engraved upon them, the figure of the deceased

Brattishing, anciently, carved open work

Bray, anciently a bank or earthen mound

Brazed, in heraldry, three chevrons clasping one another

Brazil wood, the wood of the Cæsalpinia crista, which yields a red dye: it is imported principally from Pernambuco: the tree is large, crooked, and knotty; and the bark is thick, and equals the third or fourth of its diameter. Its principal use is for dyeing: the best pieces are selected for violin-bows and turnery

Braziletto wood is of a ruddy orange colour, principally used for dyeing, and for turnery and violin-bows

Brazing, the soldering together of edges of iron, copper, brass, &c., with an alloy of brass and zinc called spelter solder

Breaching, a strong rope used to secure the breech of a gun to the ship's side

Breadth is applied to painting when the colours and shadows are broad and massive, such as the lights and shadows of the drapery; and when the eye is not checked and distracted by numerous little cavities, but glides easily over the whole. Breadth of colouring is a prominent character in the painting of all great masters

Break, in shipping. *To break bulk*, is to begin to unload

Break, a projection or recess from the surface or wall of a building

Break joint, constructively, to disallow two joints to occur over each other

Breaker, a small cask containing water

Breaking down, in sawing, is dividing the baulk into boards or planks

Breaking joint, in joinery, is not to allow two joints to come together

Breakwater, a human contrivance to ward off and diminish the force of waves, to protect harbours, stations, &c., from the violence of tempestuous gales. Some stupendous works have been executed for these purposes, especially that at Plymouth, by the great Sir John Rennie

Breaming, cleaning a ship's bottom by burning

Breast, in mining, the face of coal-workings

Breast-fast, a rope used to confine a vessel sideways to a wharf or to some other vessel

Breast-hooks, pieces of compass or knee-timber, placed withinside a ship, to keep the bows together. The deck-holes are fayed to the timbers, and placed in the direction of the decks: the rest are placed one between each deck, and as many in the hold as are thought needful; all of which should be placed square with the body of the ship, and fayed on the planks. Breast-hooks are the chief security to keep the ship's bows together; therefore they require to be very strong and well-secured

Breast-knees, those placed in the forward part of a vessel, across the stem, to unite the bows on each side

Breast-plate, that in which the end of the drill opposite the boring end is inserted

Breast-rail, the upper rail of the balcony or of the breast-work on the quarter-deck

Breast-rope, a rope passed round a man in chains, while sounding

Breast-wheel, in mill-work, a form of water-wheel in which the water is delivered to the float-boards at a point somewhat between the bottom and top. Buckets are seldom employed on breast-wheels

Breast-work, the stantients with rails on the quarter-deck and forecastle. The breast-work fitted on the upper deck of such ships as have no quarter-deck serves to distinguish the main deck from the quarter-deck

Breech, the angle of knee-timber, the inside of which is called the throat

Breeze, small ashes and cinders used instead of coal for the burning of bricks

Breort-weall, anciently, a breast-high wall

Bressummer, a beam supporting a superincumbent part of an exterior wall, and running longitudinally below that part

Bretachiæ, anciently, wooden towers, attached to fortified towns

Brick. * * * "Let us make brick, and burn them thoroughly. And they had brick for stone, and slime had they for mortar."—*Gen.* xi. 3

Bricks are a kind of factitious stone, composed of argillaceous earth, and frequently a certain portion of sand and cinders of sea coal (called breeze), tempered together with water, dried in the sun, and burnt in a kiln, or in a heap, or stack, called a clamp. For good brick-making, the earth should be of the purest kind, dug in autumn, and exposed during the winter's frost: this allows the air to penetrate, and divide the earth particles, and facilitates the subsequent operations of mixing and tempering

The Romans made bricks of various sizes, from 2 feet to 1 foot in length, from 7 inches to 9 inches in breadth, and from 3½ inches to 1¼ in thickness. Roman bricks found in the old Roman wall at Verulam, compared with modern bricks, showed the superiority of the old to the new; the Roman bricks being lighter and better burnt than the modern.

The brick remains of the period of the Roman empire are more entire than the stone. Bricks were found at Toulouse, quite sharp at the edges, and not altered by time; they measured 14 inches long, 9 inches broad, and 1½ thick. These bricks formed the foundation all around the building. The

arches were formed of them for entrances; and round, large, water-worn pebbles of quartz with mortar, formed the walls of the circus, resting on the brick arches.

Mr. Layard, in his work on Nineveh, says—"The soil, an alluvial deposit, was rich and tenacious: the builders moistened it with water, and adding a little chopped straw, that it might be more firmly bound together, they formed it into squares, which, when dried by the heat of the sun, served them as bricks. In that climate, the process required but two or three days. Such were the earliest building materials, and as they are used to this day, almost exclusively, in the same country.

"The Assyrians appear to have made much less use of bricks baked in the furnace than the Babylonians; no masses of brick-work, such as are every where found in Babylonia Proper, existing to the north of that province. Common clay moistened with water, and mixed with a little stubble, formed, as it does to this day, the mortar used in buildings; but, however simple the materials, they have successfully resisted the ravages of time, and still mark the stupendous nature of the Assyrian structures.

"This mode of brick-making is described by Sanchoniathon: The people of Tyre invented the art of brick-making and of building of huts; after them came two brothers: one of them, Chrysor or Hyphæstus, was the first who sailed in boats; his brother invented the way of making walls with bricks. From the generation were born two youths, one called Technites and the other Genius Autochthon. They discovered the method of mingling stubble with the loam of the bricks, and drying them in the sun; they also invented tiling."

Bricks. Some of Palladio's finest examples are of brick: the cortile of the Carità at Venice is an instance. The interiors of the Redentore and St. Giorgio, in the same city, have but a coat of plaster on them; the beautiful Palazzo Thiene at Vicenza, at least that part which was executed, is left with its rock-worked basement in brick-work chipped out. Form alone fastens on the mind in works of art: the rest is meretricious, if used as a substitute to supersede this grand desideratum

Brick axe, used for axing off the soffits of bricks to the saw-cuttings, and the sides to the lines drawn: as the bricks are always rubbed smooth after axing, the more truly they are axed, the less labour there will be in rubbing

Brick groins, the intersecting or meeting of two circles upon their diagonal elevations drawn upon the different sides of a square, whose principal strength lies in the united force of elevation divided by geometrical proportions to one certain gravity

Bricklaying, the art by which bricks are joined and cemented, so as to adhere a sone body. This art, in London, includes the business of walling, tiling, and paving with bricks or tiles

Brick-nogging, brick-work carried up and filled in between timber framing

Brick trimmer, a brick arch abutting upon the wooden trimmer under the slab of a fire-place, to prevent the communication of fire

Brick-trowel, a tool used for taking up mortar and spreading it on the top of a wall, to cement together the bricks, &c.

Bridge, a constructed platform, supported at intervals, or at remote points, for the purpose of a road-way over a strait, an inlet or arm of the sea, a river, or other stream of water, a canal, a valley, or other depression, or over another road: it is distinguished from a causeway, or embanked or other continuously supported road-way, and from a raft, by being so borne at intervals or at remote points.

Constructions of the nature and general form and arrangement of bridges,—such as aqueducts and viaducts; the former, being to lead or carry streams of water or canals, and the latter, to carry roads or railways upon the same, or nearly the same level, over depressions,—are in practice considered as bridges, although they are not such in the commonly received sense of the term. Taken, however, in the sense which the most plausible etymology that has been suggested of the term would require, the word bridge being formed by prefixing the constructive *be* to *ridge*, a bridge is an elevated construction upon, or over a depression, and between depressed points.

There are bridges built of the materials, stone, brick, iron, timber, wire, and on the principles of suspension; for the explanation of which, see the word *Suspension.*

The bridge across the Zab, at Lizari, is of basket-work. Stakes are firmly fastened together with twigs, forming a long hurdle, reaching from one side of the river to the other. The two ends are laid upon beams, resting upon piers on the opposite banks. Both the beams and the basket-work are kept in their places by heavy stones heaped upon them. Animals, as well as men, are able to cross over this frail structure, which swings to and fro, and seems ready to give way at every step. These bridges are of frequent occurrence in the Tiejari mountains.

Bridges. The principal object to be observed in forming the plan of a bridge, is to give a suitable and convenient aperture to the arches, so as to afford a free vent to the waters of sudden floods or inundations, and to secure the solidity and duration of the edifice by a skilful construction. The solidity of a bridge depends almost entirely on the manner in which its foundations are laid. When these are once properly arranged, the upper part may be erected either with simplicity or elegance, without impairing in any degree the durability of the structure. Experience has proved, that many bridges either decay, or are swept away by sudden floods, by reason of the defective mode of fixing their foundations, while very few suffer from an unskilful construction of the piles or arches. This latter defect, however, is easy of correction, nor is it difficult to prevent the consequences that might be expected from it.

In the projection of a bridge, five principal points are necessary to be considered,—first, the choice of its position or locality; secondly, the vent, or egress that must be allowed to the river; thirdly, the form of the arches; fourthly, the size of the arches; fifthly, the breadth of the bridge.

Bridge-board, or notch-board, a board on which the ends of the steps of wooden stairs are fastened

Bridged gutters are made with boards supported by bearers, and covered above with lead

Bridge-stone, a stone laid from the pavement to the entrance-door of a house, over a sunk area, and supported by an arch

Bridging-floors, floors in which bridging joists are used

Bridging-joists are the smallest beams in naked floorings, for supporting the boarding for walking upon

Bridging-pieces, pieces placed between two opposite beams, to prevent their nearer approach, as rafters, braces, struts, &c.

Bridle, the spans of rope attached to the leaches of square sails, to which the bow-lines are made fast

Bridle-cable, in navigation. When a vessel is moored by laying down a cable upon the ground, with an anchor at each end, then another cable attached to the middle of the ground cable is called bridle-cable

Bridle-part, the foremost part, used for stowing the anchors

Brig, a square-rigged vessel with two masts

Brine-pump, the pump in a steam-ship, used occasionally for drawing off a sufficient quantity of water, to prevent the salt from depositing in the boiler

Brittleness, in iron, is a want of tenacity or strength, so as to be easily broken by pressure or impact: when iron is made too hot, so as to be nearly in a state of fusion, or so hard as to resist the action of the file, this is called the disposition of cast iron

Broach, an old English term for a spire; still in use in some parts of the country to denote a spire springing from the tower without any intermediate parapet

Broach-to, to fall off so much, when going free, as to bring the wind round on the other quarter, and take the sails a-back

Broadside, the whole side of a vessel

Broken back, the state of a vessel when she is so loosened as to droop at each end

Bromine, in chemistry, is found combined with silver in a few ores, also in sea-water and salt-springs; as bromide of potassium, sodium, or magnesium

Brontern, in Greek architecture, brazen vessels placed under the floor of a theatre, with stones in them, to imitate thunder

Bronze, a compound metal, made of from 6 to 12 parts of tin and 100 parts of copper

Brood, in mining, any heterogeneous mixture among tin or copper ore, as Mundick, Black Jack, &c.

Browning, a process by which the surfaces of articles of iron acquire a shining brown lustre: the material used to produce this is the chloride of antimony

Brown ink. Various compounds were used in sketching by Claude, Rembrandt, and many of the old masters, the principal of which were solutions of bistre and sepia

Brown ochre, Spruce ochre, or *Ochre de Rue*, a kind of dark-coloured yellow ochre: it is much employed, and affords useful and permanent tints. This and all natural ochres require grinding and washing over, to separate them from extraneous substances; and they acquire depth and redness by burning

Brown-pink, a fine glazing colour having but little strength of body. In the flesh, it should never join or mix with the lights, because this colour and white antipathize and mix of a warm dirty hue; for which reason their joinings should be blended with a cold middle tint

Brown-post, a name given by some builders to a beam laid across a building

Brown spar, a magnesian carbonate of lime, tinged by oxide of iron and manganese

Bruiser, a concave tool used in grinding the specula of telescopes

Brunswick green, a pigment composed of carbonate of copper with chalk or lime

Brush-wheels are used in light machinery, to turn each other by means of bristles or brushes fixed to their circumference

Buata, anciently an arch or chamber; a crypt

Bucca, anciently an almonry

Bucentaur, the name of the once celebrated galley of Venice, used by the Doge on Ascension-day, to celebrate the wedding of the Adriatic, by dropping a ring into that sea

Buckers, in mining, bruisers of the ore

Buckets, in water-wheels, a series of cavities placed on the circumference of the wheel, and into which the water is delivered, to set the wheel in motion. By the revolution of the wheel the buckets are alternately placed so as to receive the water, and inverted so as to discharge it; the loaded side always descending

Bucking, in mining, a term applied to a method of breaking the poor foul copper ore smaller by hand, with small flat irons, called bucking-

ing-irons, in order to wash and separate the pure ore from the useless waste: the same term is used in the lead-mines; but Pettus, in his 'Plata Miner,' gives it the signification of washing or wet-stamping ores

Bucking-iron, in mining, the tool with which the ore is pulverized

Buckle, in heraldry, a token of surety, faith, and service in the bearer

Buckler, a shield of armour, anciently used in war

Bucklers, in ships, blocks of wood made to fit in the hawse-holes, or holes in the half-ports, when at sea

Bucranes, in sculpture, the heads of oxen, flayed and lacerated, sometimes represented on friezes

Buddle, in mining, a pit dug in the earth near the stamping-mill, 7 feet long, 3 feet wide, and 2½ feet deep, where the stamped tin is curiously washed from its impurities by water constantly running through the buddle, while a boy, called a buddle-boy, is standing in the body of it, and working both with a shovel and with his feet

Budget, a pocket used by tilers for holding the nails in lathing for tiling

Buffers, in locomotive engines, rods with enlarged ends or striking blocks projecting from the ends of the frame of a railway carriage, and attached to springs, for deadening the shocks received from the engines

Buhl, unburnished gold

Buhl-work, ornamental furniture, in which tortoise-shell is inlaid with wood and brass

Builder, a term applied to buildings in civil and naval architecture: in the former he is mostly employed under the superintendence of an architect by contract, or at measure and value; the latter, under the naval architect, mostly by contract

Building, the art which comprises all the operations of an architect in building with stone, brick, timber, iron, cement, &c.

Buildings. Of the aspects best adapted *to convenience and* health, for the different kinds of buildings, Vitruvius writes: "The principles which should be attended to in allotting to each kind of building an appropriate aspect remain to be explained: the winter eating-rooms and baths ought to face the winter-west, because the use of them requires that they should be light at the time of the sun's setting: besides which, the western sun, being immediately opposite to them, renders their temperature mild at the close of the day. The sleeping apartments and libraries should be made to front the east, because the morning light is necessary for them; and books are better preserved when the air and light are received from that quarter. When libraries have a southern or western aspect, they admit those winds, which, at the same time that they carry with them moths, instil also damp vapours into the books, which, in process of time, cause their decay. The vernal and autumnal triclinia should face the east, because the windows being turned from the sun's rays, whose heat increases as the sun advances towards the west, their temperature is cool at the hours they are generally used. The summer triclinia should front the north; because, having that aspect, they will be least exposed to the sun, and the temperature of the apartments will be grateful, at the same time that it is conducive to health. No other aspect possesses equal advantages; for the sun, during the solstice, would render the air of all others sultry. This aspect is necessary for pinacothecæ and the apartments in which the pursuits of embroidery and painting are followed, because the colours used in works of this kind retain their brightness longer when exposed to an equable and regular light."—Wilkins's Vit. p. 220.

Buildings Act, an Act of Parliament passed in the 7th and 8th of Victoria to regulate the construction of

buildings generally, and appurtenances thereto, and to determine their supervisions by district surveyors and referees

Building of beams, the joining of two or several pieces of timber together in one thickness, and of several pieces in one length, by means of bolts, so as to form a beam of given dimensions, which it would be impossible to obtain from a single piece of timber

Buleuteria, among the Greeks, council-chambers or public halls

Bulge, that part of a ship which bulges out at the floor-heads, to assist the ship when taking the ground

Bulge-way, a large piece of timber, or pieces bolted together, making one solid piece, placed under the bulge of a ship, to support her launch. The support of the bulge-ways to lie on is called ways, which sometimes are placed straight and sometimes cumber: but if they do cumber, it should be truly circular; though sometimes the curve is quicker at the lower part, but this is liable to strain the sheer of the ship. Their extreme distance is generally about one-third the breadth of the ship, but this must depend on the form of the mid-ship bend

Bulk, the contents of the hold of a ship

Bulk-heads, partitions built up in several parts of a ship, to form and separate the various apartments

Bullantic, so-called ornamental capital letters, used in apostolic bulls

Bullen-nails, such as have round heads with short shanks, turned and lacquered, used principally for hangings of rooms

Bullet wood, from the West Indies, is the produce of a large tree with a white sap; is of a greenish hazel, close and hard; used in the country for building purposes

Bullet wood, another species, from Berbice, is *of a hazel-brown colour, adapted to general and eccentric turning*

Bull's-eye, a small circular aperture for the admission of light or air

Bull's-eye, a small oval block of hard wood without sheaves, having a groove round the outside, and a hole in the middle

Bulwarks, the wood-work round a vessel, above her deck, consisting of boards fastened to stanchions and timber-heads

Bumboats, those which lie alongside a vessel in port with provisions for sale

Bumpkins, pieces fitted above the main-rail in the head, which extend nearly as far forward as the fore-part of the knee of the head, and are for the use of hauling down the fore-tack

Bunch, or *Bunchy*: a mine that is sometimes rich and at other times poor, is said to be *bunchy*

Bunch, or *Squat*, in mining, a quantity of ore, of small extent, more than a stone and not so much as a course: a mine is said to be *bunchy* when these are found in place of a regular lode

Bundle-pillar, a column or pier, with others of small dimensions attached to it

Bunny, in mining, of tin or copper ore; a sombrero in Alonzo Barba; a pipe of ore; a great collection of ore without any vein coming into or going out from it

Bunt of a sail, the middle part formed into a bag or cavity, that it may gather more wind

Buntine, thin woollen stuff, of which a ship's colours are made

Bunt-line cloth, the lining sewed up the sail in the direction of the bunt-line, to prevent the rope from chafing the sail

Bunt-lines, ropes fastened to cringles on the bottoms of the square sails, to draw them up to their yards

Buoy, a cask, or block of wood, fastened by a rope to an anchor, to point out shoals or particular spots

Burden, in mining, the tops or heads of stream-work which lie over the stream of tin, and which must be first cleansed

Burdon, a pilgrim's staff

Bureau, a chamber or office for the transaction of state or business affairs

Burges, the Persian word for Towers, evidently the same as the Gothic *burgh;* a fortified dwelling or enclosed town. *Gird* or *gard* is in Persian a city or fortress, which approximates to *garth*, an enclosure, in the Gothic: hence *garden*. But a castle, comprehending towers and walls, is in Persian *calaa*

Burgundy pitch, a resin collected from the spruce fir

Burgus, anciently a number of houses protected by a fortress

Burgward, anciently the custody or keeping of a castle

Burg-work, anciently applied to a castle or borough

Burin, an engraver's instrument; a graver

Burners, for gas-light. Coal-gas has now been used for the purposes of artificial illumination nearly fifty years, and the burners sanctioned by the companies at the present day are of several shapes.

Carburetted hydrogen of the specific gravity ·390 (which is about the density of gas when arrived at the point where it has to be burnt) requires two volumes of pure oxygen for its complete combustion and conversion into carbonic acid and water. Atmospheric air contains, in its pure state, twenty per cent. of oxygen, — in populous towns less; but twenty per cent. may be taken as a fair average: 1 cubic foot of carburetted hydrogen then requires for its proper combustion 10 cubic feet of air; if less be admitted on to the flame, a quantity of free carbon will escape (from its not finding a proper volume of oxygen for conversion into carbonic acid), and be deposited in the form of dense black smoke. When the flame from an Argand burner is turned up high, the air which rushes through the interior ring becomes *decomposed* before it can reach the air on the top of the flame, which consequently burns in one undivided mass, the gas being in part unconsumed, the products unconverted, and carbon deposited abundantly.

If an excess of air is admitted, it would appear at first to be of no consequence, but it will be found that the quantity of nitrogen accompanying this excess has a tendency to extinguish the flame, while it takes no part in the elective affinity constantly going on between the several elementary gases, viz. hydrogen, oxygen, and the vapour of carbon; and also that the quantity of atmospheric air passing through the flame unchanged, tends to reduce the temperature below that necessary for ignition, and therefore to diminish the quantity of light. For the proper combustion of the gas, neither more nor less air than the exact quantity required for the formation of carbonic acid and water can be admitted through the flame without being injurious. It is not possible practically to regulate the supply of air to such a nicety: it is preferred therefore to diminish the quantity of light by having a slight excess of air rather than to produce smoke by a deficiency, the former being unquestionably the least evil.

Burning-glass, a glass lens, which, being exposed directly to the sun, refracts the rays which fall upon it into a focus

Burning-house, the furnace in which tin ores are calcined, to sublime the sulphur from pyrites: the latter being thus decomposed, are more readily removed by washing

Burnisher, a tool used for smoothing and polishing a rough surface. Agates, polished steel, ivory, &c., are used for burnishing

Burnt Carmine is, according to its name, the carmine of cochineal partially charred till it resembles in colour the purple of gold, for the uses of which in miniature and water painting it excels

Burnt Sienna earth is, as its name implies, the terra di sienna burnt, and is of an orange-russet colour

Burnt Umber, a pigment obtained from a fossil substance, which when burnt assumes a deeper and more russet hue: it contains manganese and iron, and is very drying in oil, in which it is employed as a dryer. It is a fine warm brown, and a good working strong colour, of great use for the hair of the human head, and mixes finely with the warm shade

Burnt Verdigris is an olive-coloured oxide of copper deprived of acid. It dries well in oil, and is more durable, and in other respects an improved and more eligible pigment than in its original state

Burré-stone, a mill-stone which is almost pure silex: the best kind is of a whitish colour

Burrock, a small weir or dam, where wheels are laid in a river for catching fish

Burrow, in mining, the heap or heaps of attle, deads, or earth (void of ore), which are raised out of a mine, and commonly lie around the shafts; any heap or hillock of deads or waste

Burr-pump, a bilge-pump worked by a bar of wood pulled up and down by a rope fastened by the middle

Bursa, a bag; a purse used in the middle ages for the purposes of a little college or hall for students

Bursar, one to whom a stipend is paid out of a fund set apart for poor students; the treasurer of a college

Bursary, the treasury of a college

Bursery, the exchequer of collegiate and conventual houses, and for paying and receiving monies

Burthen, the weight or measure of capacity of a ship. Multiply the length of the keel, the inner midship breadth, and the depth from the main-deck to the plank joining the keelson together; and the product, divided by 94, gives the tonnage or burthen

Burton, a manor; a manor-house

Burton, in a ship, a small tackle of two single blocks, named from the inventor

Bush, in machinery, a piece of metal fitted into the plummer-block of a shaft in which the journal turns. The guide of a sliding-rod also bears the same name

Bush, a circular piece of iron or other metal, let into the sheaves of such blocks as have iron pins, to prevent their wearing

Bushel, a dry measure of 8 gallons or 4 pecks

Bush-harrow, an implement used in harrowing grass lands

Buskin, a high shoe or boot worn anciently, in tragedy, on the stage

Buss, a small sea-vessel used in the herring-fishery

Bust, in sculpture, the head, neck, and breast of a human figure

Bustum, anciently a tomb

But, the end of a plank where it unites with another

But-hinges, those employed in the hanging of doors, shutters, &c.

Butmen cheeks, the two solid sides of a mortise varying in thickness

Butments, the supports on which the feet of arches stand

Butterfly-valve, the double valve of an air-pump bucket, consisting of two clack-valves, having the joints opposite and on each side of the pump-rod

Butteris, an instrument of steel set in a wooden handle, used by farriers for paring the hoof of a horse

Buttery, a cellar in which butts of wine are kept; a place for provisions

Buttock, the round part of a ship abaft, from the wing transom to the upper water-line, or lower down

Buttress, in Gothic architectural structures, a pilaster, pier, or masonry added to and standing out from the exterior of a wall

Buttress, a piece of strong wall that stands on the outside of another wall, to support it

By, said of a vessel when her head is lower in the water than her stern; if her stern is lower in the water, she is *by the stern*

Byard, a piece of leather across the breast, used by those who drag the sledges in coal-pits

Byzantine Architecture. About the year A. D. 328, Constantine, who had previously resided at Rome, commenced his new capital in the East, which was called after his name, and in May, 330, was solemnly dedicated to the Virgin Mary. He adorned it with so many stately edifices that it nearly equalled the ancient capital itself: he here built a cathedral dedicated to Santa Sophia or the Eternal Wisdom, and a church to the Apostles. This cathedral, having been twice destroyed by fire, was finally rebuilt about 532 A. D., by Justinian, who had invited the celebrated architect Anthemius to Constantinople for that purpose. It was completed in six years from the time of laying the first stone.

The emperor, in his admiration of this magnificent edifice, is said to have exclaimed, "I have vanquished thee, O Solomon:" and with justice might he glorify himself; for the dome of St. Sophia is the largest in the world, and the more to be admired in its construction from the lowness of the curvature.

This church, after twelve centuries, remains the same, with the exception of the mode of worship to which it is devoted. It still retains its former name, but the Mahometans, instead of the Christians, possess it.

This is the earliest Byzantine building extant, totally dissimilar in arrangement to the Christian churches in the empire.

The plan of the interior is that of a Greek cross, the four arms of which are of equal length; the central part is square, the sides are about 115 feet in length. At each angle of the square a massive pier has been carried, 86 feet in height from the pavement, and four semicircular arches stretch across the intervals over the sides of the square, and rest on the piers. The interior angles between the four piers are filled up in a concave form. At 145 feet from the ground is the level of the springing of the dome, which is 115 feet in diameter; the form is a segment of a circle, and the height is equal to one-sixth of its diameter at the base. On both the eastern and western side of the square is a semicircular recess, with domes that rest against the main arches, and assist in resisting the lateral thrust. On the north and south sides of the square are vestibules forming a square on the plan. Above the vestibules are galleries appropriated to women during the performance of worship. The whole church is surrounded by cloisters, and enclosed by walls.

The total cost of St. Sophia has been reckoned at the lowest computation to have exceeded one million pounds; as before the building was 4 feet out of the ground, its cost had amounted to a sum equivalent to £200,000 sterling.

Besides this cathedral, Justinian is said to have built, at Constantinople, twenty-five churches to the honour of Christ, the Virgin, and the Saints; he also built a church to St. John at Ephesus, and another to the Virgin at Jerusalem: the bridges, hospitals, and aqueducts erected by this emperor were numerously distributed throughout the empire.

Byzanteum artificium, Mosaic-work

CAB CAB

CABBLING. The process in the manufacture of iron, which in Gloucestershire is called 'scabbling,' or, more correctly, 'cabbling,' may be thus described. When the cast or pig iron has been subjected to the

influence of a refinery, the product is called 'Finery:' it is then carried to the forge, and smelted in a furnace with charcoal: in a short time, a large ball, about 2½ cwt., is formed by working with an iron bar; this ball is then taken to a large hammer, and beaten into a flat oval or oblong shape, from 2 to 4 inches in thickness: this is allowed to cool, when 'cabbling' commences, and which is simply breaking up this flat iron into small pieces. Men are especially allocated for this operation, and are named 'cabblers.' The pieces of iron obtained by cabbling are then heated in another furnace almost to fusion, hammered down into shape, and ultimately drawn out into bar-iron

Cabin, a room or apartment in a ship where any of the officers usually reside, and also used in passenger vessels for the residence of passengers

Cabinet pictures, usually denominated so, are small valuable paintings from the old masters, painted on copper, panel, or canvas. Modern subjects, if painted small in size, should equally be called Cabinet

Cabinets, in Tudor times, were of massive proportions, carved in oak, ebony, walnut, and other woods, inlaid. Some of them answered the double purpose of depositories and cupboards for plate, from having drawers and recesses, or ambries, enclosed by doors; and broad shelves between the tiers of turned columns were conspicuous objects in these apartments

Cable, a thick stout rope, made of hemp, &c., to keep a ship at anchor

Cable-moulding, a bead or torus moulding, cut in imitation of the twisting of a rope, much used in the later period of the Norman style

Cabling, a round moulding, frequently used in the flutes of columns, pilasters, &c.

Caduceus, an emblem or attribute of Mercury; a rod entwined by two winged serpents

Cælatura (Greek), a branch of the fine arts, under which all sorts of ornamental work in metal, except actual statues, appear to be included

Cæmenticius, built of unhewn stones; large irregular masses laid together without mortar, having the interstices filled in with small chippings

Caen stone, a peculiar quality of stone used for building purposes, principally for Gothic structures; it is taken from quarries in Normandy

Caisson, a wooden frame or box with a flat bottom, made of strong timbers firmly connected together; used for laying the foundations of a bridge in situations where the coffer-dam cannot be adopted

Caisson, a name given to the sunk panels of various geometrical forms symmetrically disposed in flat or vaulted ceilings, or in soffits generally

Cal, in Cornish mining, a kind of iron Gossan stone found in the bryle and backs of lodes, much of the colour of old iron; reckoned a poor brood with tin

Calcar, a small oven or reverberatory furnace, in which the first calcination of sand and potashes is made for turning them into frit, from which glass is ultimately made

Calcareous earth, the same as lime, and of which there are various combinations, as marble, limestone, marl, gypsum, &c.

Calcatorium, among the Romans, a raised platform of masonry in the cellar attached to a vineyard

Calcination, the process of subjecting a body to the action of fire, to drive off the volatile parts, whereby it is reduced to a condition that it may be converted into a powder: thus marble is converted into lime by driving off the carbonic acid and water; and gypsum, alum, borax, and other saline bodies are said to be calcined when they are deprived of their water of crystallization

Calcium, the metallic basis of lime

Calcography, to write, engrave, &c.

Calculating machines are of early in-

vention; but recently Mr. Babbage has completed a calculating machine surpassing all previous ones: the machine accomplishes the additions of numbers by the movements of a number of cylinders having on the convex surface of each the series of numbers 1 2 3 4 5 6 7 8 9 0; and the operations are of two kinds: by the first the additions are made, and by the second there is introduced the 1, which should be carried to the ten's place every time that the sum of the two numbers is greater than 10, &c.

Caldarium, the hot bath. The vase which supplied the hot bath was likewise so termed

Caldarium, according to Vitruvius, the thermal chamber in a set of baths

Calender, a mechanical engine for dressing and finishing cloths

Calends, in Roman antiquity, the first day of every month

Caliber or *Caliper compasses;* compasses made with bowed or arched legs, for the purpose of taking the diameter of any round body

Caliber, an instrument used by carpenters, joiners, and bricklayers, to see whether their work be well squared

Calico, a cloth made from cotton wool, like linens; the origin of the name is from Calicut, in India

Calico printing, the art of applying coloured patterns on a white or coloured ground of linen or cotton

Calk, a Cornish term for lime

Callipers, a species of compasses with legs of a circular form, used to take the thickness or diameter of work, either circular or flat; used also to take the interior size of holes

Callipers, in turning, compasses with each of the legs bent into the form of a curve, so that when shut the points are united; and the curves, being equal and opposite, enclose a space. The use of the callipers is to try the work in the act of turning, in order to ascertain the diameter or the diameters of the various parts. As the points stand nearer together at the greatest required diameter than the parts of the legs above, the callipers are well adapted to the use intended

Callys or *Killas* (Cornish), hard, smart; the most common and agreeable stratum in our mine country, usually called killas

Caloric, the matter and cause of heat

Calorific, in chemistry, the quality of producing heat

Calorimeter, an instrument to measure the heat given out by a body in cooling by the quantity of ice it melts

Calquing, the process of copying or transferring a drawing. It is effected by rubbing over the back of the original with a fine powder of red chalk or black lead; the smeared side is then laid on a sheet of paper, and the lines of the drawing are traced by a blunt-pointed needle, which imprints them on the paper underneath. Another method is to hold the drawing up to a window with a sheet of paper before it: the outlines will appear through, and may be pencilled off without damage to the original

Calyon, flint or pebble stone, used in building walls, &c.

Cam, in steam machinery, a plate with curved sides, triangular or otherwise, fixed upon a revolving shaft, for changing the uniform rotatory motion into an irregular rectilineal motion. It is sometimes used for moving the slide-valves

Camaieu, a term used in painting when there is only one colour, the light and shades being of gold, or on a golden and azure ground. It is chiefly used to represent basso-rilievo

Camber, the convexity of a beam upon the upper surface, in order that it may not become concave by its own weight, or by the binder it may have to sustain, in the course of time

Camber-beams are those used in the flats of truncated roofs, and raised in the middle with an obtuse angle, for discharging the rain-water towards both sides of the roof

Camber-slip, a piece of wood, generally about half an inch thick, with at least one curved edge rising about 1 inch in 6 feet, for drawing the soffit-lines of straight arches: when the other edge is curved, it rises only to about one-half of the other, viz. about half an inch in 6 feet, for the purpose of drawing the upper side of the arch so as to prevent it from becoming hollow by the settling of the bricks. The upper edge of the arch is not always cambered, some persons preferring it to be straight. The bricklayer is always provided with a camber-slip, which being sufficiently long, answers to many different widths of openings: when he has done drawing his arch, he gives the camber-slip to the carpenter, in order to form the centre to the required curve of the soffit

Cambering, a sea phrase, used when a deck is higher in the middle than at the ends

Camel, the name of a machine used by the Dutch for carrying vessels heavily laden over the sand-banks in the Zuyder Zee

Camera (Greek), an arched or vaulted roof, covering or ceiling, formed by circular bands or beams of wood, over the intervals of which a coating of lath and plaster was spread: they resembled, in their construction, the hooped awnings now commonly in use

Camera-lucida, and *Camera-obscura*, (the light and dark chamber,) the names given to two methods, similar in principle, of throwing images of external objects upon plane or curved surfaces, for the purpose of drawing or amusement: in the first contrivance there is no chamber; but as it was the last invented, and as its predecessor had been called the 'camera-obscura,' it was termed the 'camera-lucida'

Camerated, a term applied to the roof of a church

Cames, the slender rods of metal used by *glaziers as turned lead*; they are usually cast in lengths which measure 12 or 14 inches

Caminus, according to Pliny, a smelting furnace

Campanæ or *Campanulæ*, or *Guttæ*, the drops of the Doric architrave

Campanile, from the Italian, a bell-tower, principally used for church purposes, but now sometimes for domestic edifices

Camphor wood is imported from China and the Indies in logs and planks of large size, and used in England for cabinet-work and turnery

Campus Martius, a district outside the walls of ancient Rome, between the Quirinal and Pincian Mounts and the Tiber, dedicated to Mars: there public exercises were performed, and the consuls and other magistrates elected: it was adorned with statues, columns, arches, &c., and much frequented by the citizens

Cam wood, the best and hardest of the red dye-woods: it is brought from Africa, and used in ornamental and eccentric turnery

Canal, an artificial water-course for connecting rivers or lakes; a navigable communication

Canalis, in Latin, a water-pipe or gutter; used in architecture for any channel, such as the flutings of columns; the channel between the volutes of an Ionic column

Canary wood, from South America, is a sound, light, orange-coloured wood, used for cabinet-work, musketry, and turnery

Cancelli, among the Romans, iron gratings and trellis-work; in modern buildings, latticed windows made with cross-bars of wood, iron, lead, &c.

Candela, a candle, made either of wax or tallow; used generally by the Romans before the invention of lamps

Candelabrum, originally a candlestick, but afterwards used to support lamps

Candlemas, the popular name for the feast of the Purification of the Virgin Mary, February 2, derived

from the lights which were then distributed and carried about in procession

Candlestick of gold (*The*) was made by Moses for the service of the Temple, and consisted wholly of pure gold: it had seven branches, upon the extremities of which were seven golden lamps, which were fed with pure olive oil, and lighted every evening by the priest on duty: it was used in the holy place, and served to illumine the altar of incense and the table of shew-bread, which stood in the same chamber

Candlesticks. The magnificence of these articles was at first displayed in chapels and in domestic apartments, as banquets in early times were given by daylight. We find them, however, of very costly descriptions. In Henry the Eighth's temporary banqueting-room, at Greenwich, "the candlestykes were of antyke worke, which bare little torchetts of white waxe: these candlestykes were polished lyke ambre."

Cangica wood, from South America, is of a light and yellow-brown colour, used for cabinet-work and turnery

Can-hooks, strings with flat hooks at each end, used for hoisting barrels or light casks

Canopy, a covering or hood, the enriched projecting head to a niche or tabernacle. The tablet or dripstone, whether straight or circular, over the heads of doors or windows, if enriched, is so called

Canopy, in Gothic architecture, an ornamental projection over doors, windows, &c.; a covering over niches, tombs, &c.

Cant, a term used among carpenters to express the cutting off the angle of a square

Cantaliver, a kind of bracket to support eaves, cornices, balconies, &c.

Canted, applied to a pillar or turret when the plan is of a polygonal form

Canterii, beams of wood in the framework of a roof, extending from the ridge to the eaves, corresponding to the rafters of a modern roof. The word canterii was also applied to two inclining reeds fixed in the ground some distance asunder and meeting at the top, for the support of vines

Cantharus, a fountain or cistern in the atrium or court-yard before ancient churches, at which persons washed before they entered the sacred buildings

Canthus, in Greek and Latin, the tire of a wheel; a hoop of iron or bronze fastened on to the felloe, to preserve the wood from abrasion

Cantilevers are horizontal rows of timbers, projecting at right angles from the naked part of a wall, for sustaining the eaves or other mouldings

Cant-moulding, a bevelled surface, neither perpendicular to the horizon nor to the vertical surface to which it may be attached

Cantoned, in architecture, is when the corner of a building is adorned with a pilaster, an angular column, rustic quoins, or any thing that projects beyond the wall

Cant-pieces, in ships, pieces of timber fastened to the angles of fishes and side-trees, to supply any part that may prove rotten

Cant-timbers, in ship-building, those timbers or ribs of the ship which are situated afore or abaft, or at the two ends, where the ship grows narrower below

Cant-timber abaft, the chock upon which the spanker-boom rests when the sail is not set

Cantuar. The signature of the Archbishop of Canterbury, is thus abbreviated, the Christian name being usually prefixed

Canvas, the cloth of which the sails of ships are made

Caoutchouc, a substance produced by the sephonia elastica, the ficus elastica, and the urceola elastica, and many other American and Asiatic trees. It is often termed Indian

rubber, from its use in removing pencil traces from paper. There are various chemical properties which render caoutchouc valuable in the arts, but elasticity and imperviousness to water are those for which it is most prized. It is worked into a great variety of useful things for dress and for domestic purposes

Cap, a thick, strong block of wood, with two holes through it, one square and the other round, used in ship-building to confine together the head of a mast and the lower part of that next above it

Capacity, the same in sense as content or volume in pure mathematics. In physics it generally signifies the power of holding or retaining: thus we speak of the capacity of a body for heat, &c.

Capel, in mining, a stone composed of quartz, schorl, and hornblende, usually occurring in one or both walls of a lode, and more frequently accompanying tin than copper ores

Capillary attraction and *repulsion*. These names have been given to the properties of matter which cause the ascent above or descent below the level of the surrounding fluid which takes place when a tube of small diameter is dipped into water, mercury, &c.

Capital, in architecture, the head or uppermost part of a column or pilaster. The capitals of the columns constitute the principal and most obvious indicial mark of the respective orders. For those of each of the three classes or orders a certain character conformable with the rest of the order is to be observed; but that attended to, further restriction is unnecessary. Between several examples, all decidedly referrible to one and the same order, very great special differences occur, and there might easily be a very great many more. Although the capital itself is indispensable, it is so only æsthetically, and not out of positive necessity. The necessity is only artistic: decoration of the kind there must be, but the express mode of it is one of those matters which should be left to design, to which it properly belongs. Capitals are just as legitimate subjects for the exercise of taste and invention as any thing else in decorative design. The capital is only an ornamental head to the column, and therefore admits of being as freely designed as any other piece of ornament, on the conditions of its being accordant in character with the rest of the order, and of forming an agreeable transition from the shaft of the column to the architrave

Capitolium, a temple or citadel at Rome, on the Tarpeian rock: it was finished by Tarquinius Superbus, and consecrated by the consul M. Horatius,—was burnt in the time of Marius, and rebuilt by Sylla,—destroyed a second and third time in the troubles under Vitellius and Vespasian, and lastly raised again by Domitian. Its name was derived from the discovery of the head of *Tolius*, during the excavation of the earth for the foundation. Q. Catulus consecrated it to Jupiter Capitolinus, and covered it with gilded brass tiles. The steep ascent of the rock was mounted by 100 steps on the side of the forum. In the temple were statues of gold and silver, vessels of those metals and of crystal, and 3000 brass tables on which the Roman laws were engraved

Caple (in Cornwall) *stone* is something like limestone, but will not burn. The walls of most lodes are of this kind, and therefore it is common to call a lode by the name of its caple: those veins which abound with it are termed caples or caple-lodes

Capreoli, the pieces of timber on a roof which serve to uphold the axes or principals. A fork inclined so as to afford support to any thing was formerly called a *Capreolus*

Capsa or *Capsula*, a box for holding books among the Romans: these

boxes were usually made of beech wood, and were cylindrical in form

Capsize, to overturn

Capstan, in naval architecture, a strong massive piece of timber let down through the decks of a ship, and resting its foot or axis, which is shod with iron, in an iron socket, called a saucer, fixed on a wooden block or standard, called the step, resting on the beams

Captain, in mining, an experienced miner; one who directs and oversees the workmen and business of a mine

Caracol, a term sometimes used for a staircase in a helix or spiral form

Caradoc formation, the uppermost of the two great divisions of the lower silurian strata of Murchison, seen principally in Shropshire, Worcestershire, Somersetshire, &c., and on the eastern borders of Wales

Caravanserai, a building in the East, expressed in our version of the Scripture by the term Inn; in Turkey it is understood to be a place of accommodation for strangers and travellers: they are built at proper distances through the roads of the Turkish dominions, and afford the indigent and weary traveller an asylum from the inclemency of the weather

Carbon, a non-metallic elementary solid body, which is widely diffused throughout nature. The purest and at the same time the rarest form in which it occurs is that of the diamond; the more common states in which it is met with are those of anthracite, graphite, and coal: another form is that of charcoal

Carbonate, a salt composed of carbonic acid and a base. The chief varieties are described under their alkaline, earthy, and metallic bases

Carburet, a compound of carbon with nitrogen, metals, &c.

Carcass (*The*) of a building is the naked walls and the rough timber-work of the flooring and quarter partitions before the building is *plastered or the floors laid*

Carcass-roofing, that which supports the covering by a grated frame of timber-work

Carcer, a prison or gaol. The Roman prisons were divided into three stories, one above the other, each of which was appropriated to distinct purposes

Card-making machine, an arrangement of wires used in the cotton manufacture, for disentangling the fibres of cotton preparatory to spinning

Cardo, a pivot and socket, an apparatus by means of which the doors of the ancients were fixed in their places, and made to revolve in opening and shutting

Careening, the operation of heaving a ship down on one side by the application of a strong purchase to her masts, which are properly supported for the occasion, to prevent their breaking with so great a strain, and by which means one side of the bottom, being elevated above the surface of the water, it may be cleansed or repaired

Carina, according to Cicero, the keel or lowest piece of timber in the frame-work of a ship

Carlings, short pieces of timber ranging fore and aft from one deck-beam to another, into which their ends are mortised: they are used to sustain and fortify the smaller beams of the ship

Carlisle Tables, so called from the more recent mode of making calculations of the value of annuities on lives, based on the average duration of human life, as taken at Carlisle, in Cumberland. The value of a life annuity depends upon the manner in which it is presumed a large number of persons, similarly situated with the buyer, would die off successively. Various tables of these decrements of life, as they are called, have been constructed from observations made among different classes of lives. Some make the mortality greater than others; and,

of course, tables which give a large mortality give the value of the annuity smaller than those which suppose men to live longer. Those who buy annuities would therefore be glad to be rated according to tables of high mortality, or low expectation of life; while those who sell them would prefer receiving the price indicated by tables which give a lower rate of mortality. Hence arise bargains or stipulations according to either the Northampton or Carlisle tabulated rating of the duration of life. In assurances the reverse is the case: the shorter the time which a man is supposed to live, the more must he pay the office, that the latter may at his death have accumulated wherewithal to pay the amount. The Northampton tables, formed by Dr. Price, from observations of burials at Northampton, as compared with all other tables of authority, give too high a mortality at all the younger and middle ages of life, and, consequently, too low a value of the annuity. The Carlisle tables, formed by Mr. Milne, give much less mortality than most of the old tables, and therefore a higher value of the annuities: they have been proved to represent the actual state of life among the middle classes

Carmine (*colour*), a name originally given only to fine specimens of the tinctures of kermes and cochineal, and denoting generally at present any pigment which resembles them in beauty, richness of colour, and fineness of texture: hence we hear of blue and other coloured carmines, though the term is principally confined to the crimson and scarlet colours produced from cochineal by the agency of tin

Carn, in Cornish mining, a rock; a heap of rocks; a high rock

Carnagioni (of the Italians), a colour which differs from terra puzzuoli in its hue; in which respect, other variations and denominations are produced by dressing and compounding

Carol, a small closet or enclosure to sit and read in

Carpenter's square: the stock and blade are formed, in one piece, of plate-iron, and the instrument is thus constructed:—one leg is 18 inches in length, numbered from the exterior angle; the bottom of the figures are adjacent to the interior edge of the square, and consequently their tops to the exterior edge: the other leg is 12 inches in length, and numbered from the extremity towards the angle; the figures are read from the internal angle, as in the other side; and each of the legs is about an inch broad. It is not only used as a square, but also as a level, and as a rule: its application as a square and as a rule is so easy as not to require any example; but its use as a level, in taking angles, may be thus illustrated: suppose it were required to take the angle which the heel of a rafter makes with the back,—apply the end of the short leg of the square to the heel-point of the rafter, and the edge of the square level across the plate; extend a line from the ridge to the heel-point, and where this line cuts the perpendicular leg of the square, mark the inches: this will show how far it deviates from the square in 12 inches

Carpenters' tools: the principal tools used in the rougher operations of carpentry are the axe, the adze, the chisel, the saw, the mortise and tenon-gauge, the square, the plumb-rule, the level, the auger, the crow, and the draw-bore-pin, or hook-pin, for draw-boring

Carpentry is the art of combining pieces of timber for the support of any considerable weight or pressure.

The theory of carpentry is founded on two distinct branches of mechanical science: the one informs us how strains are propagated

through a system of framing; the other, how to proportion the resistance of its parts, so that all may be sufficiently strong to resist the strains to which they are exposed. The one determines the stability of position, the other the stability of resistance. Each of these may be considered in the most simple manner the subject admits of, with the addition of rules and practical remarks.

Timber is wrought into various forms according to the principles of geometry; and these forms are to be preserved in their original shape only by adjusting the stress and strain according to the laws of mechanics. Hence the importance of studying both these sciences is evident, and particularly the latter; for unless the stress and strain be accurately adjusted, the most careful attention to geometrical rules, and the most skilful workmanship, will be exerted in vain. If, for instance, the centre of an arch were to be drawn and worked ever so truly to the curve required, what would it avail if the centre changed its form with every course of stone laid upon it? And it must be remarked, that this is not an imaginary case, but one that has frequently happened; and not only to men ignorant of mechanics, but to some of the most celebrated engineers that France ever produced.

The engineers of our own country have been more successful, having succeeded in gradually introducing a better principle of constructing centres than our neighbours. The greatest defect of the English centres is now an excess of strength, which, on principles of economy, it would be desirable to avoid in erections for temporary purposes

Carpentry, in civil architecture, is the art of employing timber in the construction of buildings.

The first operation of dividing a piece of timber into scantlings, or boards, by means of the pit-saw, belongs to sawing, and is previous to any thing done in carpentry.

The tools employed by the carpenter are a ripping-saw, a hand-saw, an axe, an adze, a socket-chisel, a firmer chisel, a ripping-chisel, an auger, a gimlet, a hammer, a mallet, a pair of pincers, and sometimes planes; but as these are not necessarily used, they are described under the head of joinery, in which they are absolutely necessary

Carrara marble, a species of white marble: it is distinguished from the Parian or statuary marble by being harder and less bright. It takes its name from Carrara, in Italy

Carrel, a pew, closet, or desk, with a seat placed under a window, where the monks were engaged in copying writings

Carriage of a stair, the timber which supports the steps

Carrick-bend, a kind of knot. Carrick-bitts are the windlass-bitts

Carrier, the piece of iron which is fixed by a set-screw on the end of a shaft or spindle to be turned in a lathe, to carry it round by the action of the driver of the centre chuck

Carry away, a sea term, to break a spar or part a rope

Cartoon, a distemper-coloured drawing, made on paper, linen, parchment, &c., of the exact pattern of a design intended to be executed either in tapestry, mosaics, or on glass: such are Raphael's divine pictures in Hampton Court Palace

Cartoon, in painting, a design drawn on strong paper, sometimes afterwards calqued through, and transferred on the fresh plaster of a wall, to be painted in fresco

Cartouch, the same as modillion, except that it is exclusively used to signify the blocks or modillions on the eaves of a house

Cartouche, an ornament representing a scroll of paper

Carucru, or *Chica*, a new pigment,

of a soft powdery texture and rich marrone colour, first brought from South America by Lieut. Mawe

Carving and inlaying of woods had become pretty general at the latter end of the sixteenth century: "at Hardwick, in Derbyshire (1570), the wood-work, in several of the principal apartments, is oak, inlaid with ebony ornaments on the panels and stiles. The doors and shutters of 'Mary Queen of Scot's room,' as it is called, are framed in panels of light wood, inlaid with profiles of the Cæsars, and other enrichments; the stiles, of darker coloured oak. In the state-room, the walls are divided, at about half the height, by a stringing, the upper part filled with landscapes, figures, and animals, relieved in plaster, and painted in their proper colours on white ground; and the lower division hung with tapestry. The chimney front is entirely occupied by a large armorial compartment, relieved in plaster and emblazoned"

Caryates or *Caryatides* (Greek), figures used instead of columns, employed in architecture to represent the portraiture of the defeated Persians after the subjugation of the Caryatæ. The male figures are denominated Persians, Telamones, or Atlantides: the female, Caryans or Caryatides

Caryatides, anthropostylar pillars or human figures (usually female ones) employed instead of columns to support an entablature. Such figures ought always to be perfectly free from all attitudinizing, and to appear to support their burden without any effort. Some very matter-of-fact critics object to caryatides as being at the best only beautiful absurdities; as if statues so applied were particularly liable to be mistaken for living persons subjected to a more severe punishment than that of being posted up in a niche, or on the top of a building

Casa, according to Vitruvius, a cottage; a small country-house

Cased tin, in Cornish mining, that which is re-framed by the gentlest current of water, and prevented from running off the frame by turf placed at the bottom

Case-hardening. The hardness and polish of steel may be united, in a certain degree, with the firmness and cheapness of malleable iron, by what is called case-hardening, an operation much practised, and of considerable use

Casement, a frame enclosing part of the glazing of a window, with hinges to open and shut; also an early English name for a deep hollow moulding

Casement, the same as 'scotia,' the name of a hollowed moulding

Casements, sashes or glass frames opening on hinges and revolving upon one of the vertical edges

Cases, in Cornwall, very small fissures in the strata of the earth, through which small streams of water flow when they are opened by the working underground, greatly to the hindrance of the workmen

Casing of timber-work, the plastering a house all over on the outside with mortar and then striking it wet by a ruler with the corner of a trowel, or the like instrument, to make it resemble the joints of freestone, by which means the whole house appears as if built thereof

Cassel earth, or *Castle earth*, an ochreous pigment of a brown colour, more inclined to the russet hue

Cassia Fistula is a native vegetable pigment, though it is more commonly used as a medicinal drug

Cast, to pay a vessel's head off, in getting under way, on the tack she is to sail upon

Cast after cast, in Cornwall, is throwing up of tin stuff, &c., from one stage of boards to another, each cast about 5 or 6 feet high

Castella, square towers in the celebrated Roman wall of Severus, which was raised to separate England from Scotland

Castellated, built in imitation of an ancient castle

Castellum, the receptacle in which the water was collected and heated for the public baths of the Romans; a castle

Casting, among sculptors, the taking casts of impressions of figures, busts, medals, leaves, &c.

Casting of draperies: by this term is implied the distribution of the folds, and draperies are said to be well cast when the folds are distributed in such a manner as to appear rather the result of mere chance than of art, study, or labour. In that manner or style of painting, which is called *the grand*, the folds of the draperies should be great, and as few as possible, because their rich simplicity is more susceptible of great lights; but it is an error to design draperies too heavy and cumbersome, for they ought to be suitable to the figures, with a combination of ease and grandeur. Order, contrast, and a variety of stuffs and folds, constitute the elegance of draperies; and diversity of colours in these stuffs contributes extremely to the harmony of the whole in historic compositions

Casting or *Warping*, in joinery, is the bending of the surfaces of a piece of wood from their original position, either by the weight of the wood or by an unequal exposure to the weather, or by the unequal texture of the wood

Cast-iron framing, for mill-work, possesses great superiority over that of timber, for constructing the framing. It is not only much more durable, but, from the uniformity of its texture, may be converted into any shape, so as to give it great advantage in arranging the materials with respect to strength, and proportioning it to the stress it has to sustain

Cast-iron shoes for roofs. A practice has been recently introduced into the construction of roofs having the beams of wood, of protecting their extremities from the damp and consequent decay to which they are liable, by resting immediately in contact with the brick or stone work of the walls of the building. This is effected by what the workmen call cast-iron shoes, which are attached to the ends of the tie-beams by means of bolts, nuts, &c.

The iron shoe itself, of course, takes various forms, according to circumstances and the situation where it is introduced, and the particular views of the architect who employs it.

In cases where, from the nature of the work carried on, every part is exposed to great heat and moisture, the defence afforded by such an attachment is of great importance; the wood, unless thus protected, being of course very liable to decay in those parts where damp and moisture might accumulate

Castle, a fortified and strong mansion, situated and constructed and arranged for the purpose of protecting its inmates against the assaults of enemies; in modern use, domestic residences of the nobility and gentry, without the necessity of being garrisoned by armed men

Cat, the tackle used to hoist the anchor up to the cat-head

Catacombs, subterraneous vaults or excavations used as burying-places

Catamaran, a name given both in the East and West Indies to some kinds of rafts, which are used in short navigations along the sea-shore

Cataract, a contrivance applied to Cornish engines for regulating the number of strokes per minute: it consists of a small pump fixed on a cistern; the piston is raised at each stroke of the engine by a tappet on the plug-rod, and the water rises into the cylinder of the pump; it is then forced through a cock by means of counterweights attached to a cross-head on the pump piston-rod: when the water has been forced

back into the cistern, a series of levers, acting on a rising rod, loosen catches which allow weights to act, by means of levers, to open or shut the steam, equilibrium, and exhaust valves

Cataractes, a cataract, cascade, or sudden fall of water from a higher to a lower level; according to Pliny, a sluice, flood-gate, or lock in a river

Catch, a contrivance in machinery, acting on the principle of a latch

Catenary, in the higher geometry, a mechanical curve which a chain or rope forms itself into by its own weight, when hung freely between two points of suspension, whether these points be in the same horizontal plane or not

Catgut, in turnery, the string which connects the fly and the mandril

Cat-harpin, an iron leg used to confine the upper part of the rigging to the mast

Cat-head, in naval architecture, a large square piece of timber, one end of which is fastened upon the forecastle and the other end projects without the bow, so as to keep the anchor clear of the ship when it is being drawn up by a tackle

Cathedra, according to Horace, a chair without arms; according to Juvenal, a chair with a long deep seat

Cathedral, the principal church of a diocese, in which the bishop's throne is placed

Cathedral (the very ancient) of Usumbar and other Armenian churches in Georgia have an arcade surrounding the outside of the building, of which the arches are in the flattened Gothic style: the same form prevails in the windows, doors, &c., in the body of the church. These structures are of an earlier date than any Gothic architecture in Italy

Cathedrals. Very few of the Gothic cathedrals on the Continent have the tower or spire springing from the centre of the cross, and resting on four pillars, to balance the thrusts of the ranges of arches centering there; nor have those of Strasburgh, Ulm, Vienna, Orleans, or Antwerp. "The distribution of light in a Gothic cathedral is admirably adapted to the grandeur of the edifice, and produces that effect which a painter aims at in his picture. At the entrance at the west, the window being placed high, there is a low-toned light on the lower part of the pillars, and a shadow on the pavement, which, as we walk up the nave, graduates into light from the choir. The east window, always the broadest and the highest, pours in a greater body of light than is to be found in any other kind of building. The altar, rather in shadow, surrounded by this strong light, gives additional effect by contrast. The light from the transept windows is softened down by painted glass. The small windows, placed high along the aisles, enlighten their roofs, but the lower part of the pillars and floor remain in shadow."

Cathedral churches of Great Britain:

NAME.	ORDER.	DATE.	COUNTY.
Aberdeen, Old . . .		1137	Aberdeenshire
Andrew (St.) . . .		temp. Alex. I.	Fifeshire
Asaph (St.)	Secular Canons	550	Flintshire
Bangor	Do.	550	Caernarvonshire
Bath	Benedictine	676	Somersetshire
Brechin		1140	Forfar
Bristol	Augustine	1148	Somersetshire
Canterbury	Benedictine	616	Kent
Carlisle	Augustine	686	Cumberland
Chester	Benedictine	875	Cheshire
Chichester	Secular Canons	1075	Sussex

NAME.	ORDER.	DATE.	COUNTY.
Coventry	Benedictine	1102	Warwickshire
David's (St.)	Secular Canons	577	Pembrokeshire
Dornoch			Caithness
Dornoch			Sutherland
Dublin, Cathedral of the Holy Trinity	Augustine	1170	Ireland
Dumblain			Perthshire
Dunkeld			Do.
Durham	Benedictine	990	Durham
Elgin	Dominican	1233	Moray
Ely	Benedictine	673	Cambridgeshire
Exeter	Do.	1050	Devonshire
Glasgow	Augustine	1270	Renfrewshire
Gloucester	Benedictine	680	Gloucestershire
Hereford	Secular Canons	825	Herefordshire
Iona		656	Argyleshire
Lichfield	Secular Canons	635	Staffordshire
Lincoln		635	Lincolnshire
Lindisfarne	Benedictine	635	Northumberland
Llandaff	Secular Canons	522	Glamorganshire
Manchester		9 Hen. V.	Lancashire
Norwich	Benedictine	1096	Norfolk
Oxford	Augustine	727	Oxfordshire
Paul's (St.)	Do.	604	London
Peterborough	Benedictine	970	Northamptonshire
Ripon	Secular Canons	Wm. Conq.	Yorkshire
Rochester	Benedictine	600	Kent
Ross			Ross-shire
Salisbury	Secular Canons	905	Wiltshire
Wells		766	Somersetshire
Whitehorn			Kircudbright
Winchester	Benedictine	963	Hampshire
Worcester	Do.	678	Worcestershire
York	Secular Canons	627	Yorkshire

Catherine-wheel, in architecture, an ornament that occurs in the upper part of the north and south transepts of ancient cathedrals

Cathetus. The eye of the volute is so termed because its position is determined, in an Ionic or voluted capital, by a line let down from the point in which the volute generates

Cat's-paw, a hitch made in a rope

Cauliculus, the volute or twist under the flower in the Corinthian capital

Caulking, in naval architecture, the art of driving a quantity of oakum, *i. e.* old ropes untwisted and softened, into the seams of the planks, to keep out the water

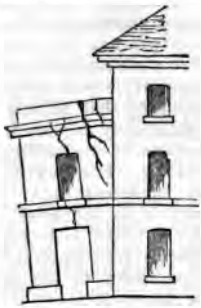
Caunter and *Caunting*, in Cornish mining, *Contra:* when two lodes run across, the one, with respect to the other, is called a *counter* or *contra* lode

Cautions in Architectural Construction.—

UNION OF NEW AND OLD WORK.

In attaching any new work to a building, every allowance must be made for the sinking of the footings under pressure, and for the settlement of the masonry into itself. Thus, while it is necessary that a vertical groove, or indent, be made in the old work, to receive a corresponding piece of the new, it is still more essential that a freedom

for the downward motion of the latter should be secured: otherwise, if it be tightly toothed and bonded into the old work, the result illustrated in the annexed sketch may be anticipated.



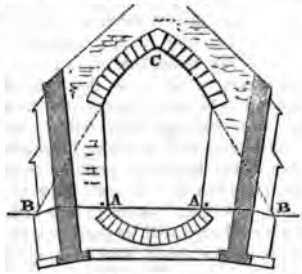
UNION OF ASHLAR FACING WITH BRICK OR RUBBLE BACKING.

The same caution required in the latter case must be here equally observed. The *backing* (composed of small material and much mortar) will settle more than the *face;* and the latter will consequently

bulge. This is easily remedied by computing, and allowing for, the difference of settlement; and by a due regard to the occasional bonding of the ashlar, so as to make the wall *one* substance, instead of *two* differently conditioned. The preceding sketch illustrates the consequence of weight pressing upon unbonded ashlar and upon yielding rubble.

INVERTED ARCHES.

Inverted arches must be used cautiously. Here is an instance,



in which the points A and A were prevented by the inverted arch from sinking with the points B B, which latter sunk the more from the pressure of the arch C in the direction of the dotted lines. It is not uncommon for the young architect to *affect* precautionary *science*, without a due consideration of the peculiar circumstances of his case.

DRAINAGE, ETC.

Always endeavour, if possible, to get your water-closet cess-pit outside the building, so that it may be approached for cleansing without disturbing the interior. Be careful in the efficient use of dip-draps to prevent the ascent of rats from the outer sewer into the drains which are under the floors of the house. Rats are destructive in their operations, and if they die in the drain, prove, for a length of time, an unbearable nuisance. Drains may serve every purpose of carrying off soil and water; but the slightest opening in their upper part will allow the escape of effluvia into the space under the ground flooring, and thence into the rooms, unless that space be thoroughly ventilated with grated openings, allowing a thorough draught,—or, at least, a free ingress of fresh air, and equal egress of foul. In the application of covered dry areas

round the excavated basements of buildings, on no account omit their entire ventilation. If this be not attended to, the main walling, which they are intended to preserve from damp, may remain even more continually moist than if in immediate connection with the natural ground. Moisture frequently rises up the walling from below its foundation, and, exuding from the face of the masonry, remains confined, unless it evaporate and escape. Without means to this end, a covered area will be merely a receptacle for damp, and may keep the masonry continually wet, even when the ground outside is perfectly dry. Be especially cautious that the water from the rain-pipes of the roofs and flats be not conducted by them into the foundations.

FIRE OPENINGS.

It will save much subsequent trouble and disturbance of masonry, to be assured as to the size and character of the stoves, grates, ranges, &c., which the proprietor will employ. In the kitchen and cooking-rooms, especially, precautionary care should be taken in suiting the openings to the intended apparatus. Do not forget to be prepared for a smoke-jack, &c.

DWARF WALLS.

In constructing these, do not omit the holes, &c., necessary for under-floor ventilation.

PAVING.

Be careful that the bottom, on which fine paving is laid, be dry and free from *staining* material. Common lime mortar is often injurious to pavements. Portland paving is especially liable to be disfigured by it.

WROUGHT STONE-WORK.

In putting wrought stone-work together, *iron* is to be avoided as the certain cause of its subsequent destruction. The stone cornices, architraves, and dressings of many a noble mansion have been brought into premature ruin by the contraction and expansion of iron under the effects of cold and heat. But there are careless contractors who will allow their Corinthian capitals and fluted shafts to be ruined, even before the entablature surmounts them; and the young architect will not, therefore, omit to insert a clause in his specification, (and to be peremptory in its enforcement,) that all cut stonework be securely preserved, during the progress of the building, with wood casing. It is surprising how grossly indifferent each class of artificers is to the work of the others. It is still more surprising to observe how frequently they seem indifferent to the preservation of their own.

SLATING.

Get rid of the masons and plasterers and plumbers before your slaters begin. The injury done to slating by the afterwork of chimney-tops, &c., is much to be dreaded. The cementitious 'stopping' to a roof will not be efficiently done without close supervision: the ridge, hip, and valley courses will not be properly formed of large cut slates,—nor will every slate have its *two* nails, unless the architect see to it.

PLASTERING.

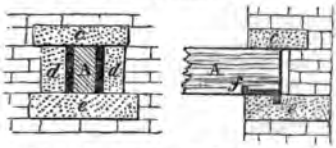
Clear may be your specification in forbidding salt sand, but, if your work be carried on in the vicinity of any estuary, the chances are (unless you be deemed cruelly strict) that the surface of your internal walls will vary with the weather, from damp to dry, like a sea-weed, and throw out salt in abundance.

BEAMS, JOISTS, AND OTHER TIMBERS.

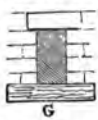
LINTELS, BOND, PARTITIONS.

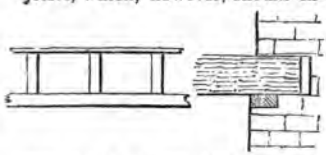
It is the office of walls to carry beams, &c.; and that of beams to stay the walls from falling outwards or inwards: but it is the duty of architects to see that the

wood-work which supplants masonry does not weaken the latter; *i. e.* that the ends of timbers inserted into walls may not, by compression or decay, leave the superincumbent masonry to loosen downwards. Thus, the beam A, though entering only a *portion* of

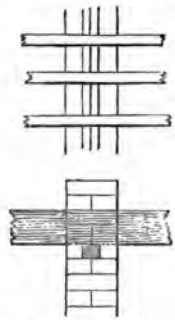


the wall, presses upon the thorough-stone *e*, which throws the weight upon the *whole* wall, and has, by means of an iron plate *c*, a hold to secure its perpendicularity. The cover-stone c presses on the surface of the timber to confirm its security: but should the timber rot, the cover-stone will not sink, because sustained by the side-stones *d d*. To *prevent* rot, the backing and side-stones are left free of the timber, so that air may traverse round it. The habit of placing the ends of beams on a template, as G, is bad. The only justification of the employment of wood, so built into the walls, is when it forms a continuous plate, that it may act as a bond to preserve the perfect horizontal level of joists, which, however, should ex-





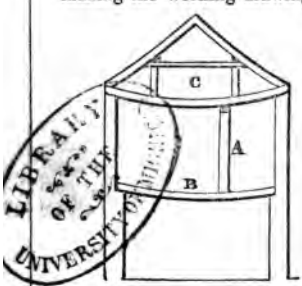
tend a little beyond the plate, so as to have a bearing also on the solid of the wall. Careful inspection will then so manage the construction of the wall in this part, as to leave it but little weakened by the air-hollows required for the plate and joists; unless, indeed, it be very thin,—as only one brick, for instance,—when no law of common sense can justify the use of continu-



ous bond. Where joists uninterruptedly cross a thin wall, which is to support another story of masonry, let there only be one plate, thin, and on its edge, in the centre of the wall, so that at least a brick on edge may be placed on each side of it, to fill up the intervals between the joists, and give solid support to the superincumbent masonry. On no account let the upper part of the wall be separated from the lower by a mere layer of perishable wood, or supported by a range of joists on their edge. It has often been seen that iron hooping should be more used than it is as the internal bonding of walls. At the same time, it must be remembered, that bond timbering is necessary, at intervals, to receive the nails of the battening. When, however, the wall is thin, it may be imperative to avoid its use, employing old oak bats for that purpose. In short, let it be the care of the young architect, so to contrive the union of his masonry and carpentry, as that the entire removal of the latter may leave the former secure in its own strength. In the use of *lintels* especially, he should be cautious. They are useful as bonds to unite the tops of

piers, and as means for the fixing of the joinery; but they ought never to be trusted to as a lasting support of masonry,—that support being always really afforded by the relieving segment arch above the lintel. A bressummer may be termed a large lintel; and by its adoption here, at least, the support of the masonry is truly intended. The use of the bressummer, in shop-front openings, is an evil necessity to which an architect must often submit; and all that he can do, is to make the best of a bad job, by *wrought*-iron trussing, which will at least give adequate *strength*, though it may not insure permanent durability. If *time* spare it, *fire* may destroy it; and the latter evil is not to be met even by iron, which, if wrought, will bend,—if cast, will crack, with heat. Let the arch, then, or some modification of it, be always used—if possible.

Partitions of wood should not be left to the sagacity of the carpenter. Under all circumstances where they have to support themselves over voids, or to bear, or participate in the bearing of, a pressure from above, they should be considered by the architect in his specification, and carefully studied in making the working drawings. It



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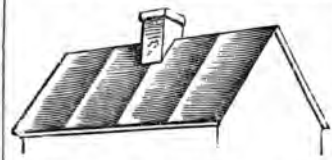
is not enough merely to say, that "they are to be trussed so as to prevent any injury to ceilings by their own pressure;" marginal sketches should be made, showing the disposition of the skeleton framing, with whatever iron-work is necessary to its security. See, for instance, what a carpenter may do, unless well directed: a roof C, bearing partly on the partition A, when it should have borne only on the walls; and, instead of distressing the partition, should have rather held it suspended: the partition A bearing down with its own weight, and that of the roof, on the floor B, instead of being so truss-framed in its length as to leave the floor unconscious of its existence. No ignorance in the young architect is presumed as to the manner of doing these things; he is merely admonished not to imagine that they are so obvious as to be done without his guidance.

In the framing of roofs, give a maximum strength to the purlins: the undulating surface of a weakly-purlined roof will soon proclaim its defect in this particular. The po-

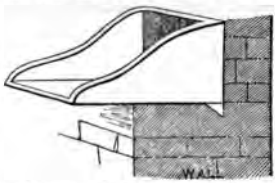


sition of the principals should not be observable from without.

FLOORS; SIMPLE AND FRAMED, ETC.

For permanent and uniform strength, there is no floor so good as one composed of simple joists, stiffened by cross bonding: but, in very large rooms, there is more economy in the compound floor of binders and joists, or of joists, binders, and girders. There may be particular reasons for girders, &c.; as, when the weight of the floor has to be thrown upon piers, and not on a continuous wall of uniform strength: but the usual motive to the use of the compound floor, in rooms which

exceed 18 or 20 feet in width, is a legitimate economy of materials. It is only necessary to caution the young practitioner on the necessity of considering, that girders have to perform the duty of cross-walls; that they should be trussed to prevent their 'sagging' even with their own weight; that their scantling should allow for the weakening effect of the cuttings made into their substance to receive the timbers they support; that their trusses should be wholly of *iron* (and not partially of oak); and, especially, that the end of each girder, instead of being notched on perishable templates of wood, and closely surrounded with mortar and masonry, should be housed in a cavity with an iron holding-plate; or inserted into a cast-iron boxing, notched into a thorough-stone, leaving a space (however small) for the air to circulate about it,



and prevent rot. The failure of a girder sometimes involves the failure of all the rest of the floor; and, though *all* timbers inserted in masonry should have a more careful regard to their preservation from decay than it is usual to bestow, it will be readily admitted, that too much care cannot be given to those leading bearing timbers, without the permanent duration of which the durability of the large remainder is of no avail.

ROOFS.

The same remarks, applying to the extremities of girders, apply also to tie-beams.

CEILINGS.

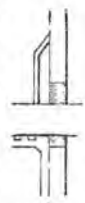
To procure a good ceiling in single-joist floors it is necessary there should be ceiling joists crossing below the others: and it is a question whether the ceiling joists, under double-framed floors, instead of being chase-mortised *into* the binders, should not be in unbroken lengths nailed *under* the binders. Where the ceiling joists (as under roofs) are likely to be trodden upon, they must be well secured.

SOUND BOARDING.

Always consider whether the occupants of any particular room will be annoyed by noises from the rooms below or above. Sound boarding and pugging considerably increase the weight of the floor, the scantling of whose timbers should, therefore, be thought upon. Water-closet partitions should be well pugged.

MICE IN PARTITIONS AND SKIRTINGS.

The space behind the skirtings is often a thoroughfare for mice, which also contrive to travel from floor to floor in the hollows of the quarter-partitions, and become in several ways a great nuisance. Plaster or wood stopping is not always so efficacious as the use of broken glass in those secret passages which they are prone to frequent.



COVERINGS TO GUTTERS, CISTERNS, ETC.

The liability of gutters and cisterns to become choked with snow, or filled up with leaves, &c., renders it advisable to protect them with a boarded covering, which may preserve the under current of water from receiving what may speedily produce a chokage or overflow.

IRON COLUMNS, BEAMS, ETC.

On this most important subject the young architect should not move a step without carefully consulting the experienced knowledge of the engineer. Tredgold's 'Prac-

tical Essay on the Strength of Cast Iron' should be well studied, whenever necessity compels the support of heavy and loaded superstructures by iron columns and beams. A careful computation of the weight of the mere building, added to that of its possible burthen, with allowance for theoretical fallacy, and a due estimate of the increased strength of the hollow pillar, as compared with a solid one having the same amount of metal, must be made, examined, and re-examined, before the specification be issued.

Cavædium, one of the courts of a Roman house, most commonly surrounded by a covered passage, having the middle area exposed to the air

Cavædia. There are five kinds of cavædia, which, from their mode of construction, are severally denominated Tuscan, Corinthian, tetrastyle, displuviatum, and testudinatum. They are termed Tuscan when the beams which are thrown across the court have timbers and gutters extending diagonally from the angles made by the walls of the court to those made by the junction of the beams, and the rafters of the eaves are made to incline every way towards the centre of the compluvium. The timbers and compluvia of Corinthian cavædia have a disposition, in all respects, similar; but beams are made to project from the walls, and are supported upon columns arranged around the court

Cavazion, in architecture, the hollow trench made for laying the foundation of a building; according to Vitruvius, it ought to be one-sixth part of the height of the whole building

Cavetto, a hollow moulding whose profile is a quadrant of a circle; principally used in cornices

Cedar. Cedar wood was known and used in the earliest times, as in the *construction of* Solomon's Temple: great varieties are produced in the eastern and western parts of the world: it is used in ship-building, cabinet-work, pencil-making, and for various other purposes

Ceiling, the upper side of an apartment, opposite to the floor, generally finished with plastered work. Ceilings are set in two different ways: the best is where the setting-coat is composed of plaster and putty, commonly called 'gauge.' Common ceilings have plaster, but no hair: the latter is the same as the finishing coat in walls set for paper

Ceiling, the under covering of a roof, under the surface of the vaulting in vaulted rooms and buildings. Ceilings in buildings of any dimensions at either story are the upper or overhead surfaces of the rooms respectively

Ceilings. When ceilings are covered, the height of the cove should be regulated by the total height of the room. In proportioning the height of a room to its superficial dimensions, the best proportion for the cove is one-quarter of the whole height

Celerity is the velocity or swiftness of a body in motion; or that affection of a body in motion by which it can pass over a certain space in a certain time

Cell, an enclosed space within the walls of an ancient temple; a term applied also to monkish sleeping-rooms in religious establishments

Cella, the body or principal part of a temple,—anciently written *cela*. It is thought to be derived from *celandus*,—to be concealed or shut out from public view; because in early temples the cella could only be entered by privileged persons

Cellarino, that part of the capital in the Roman, Doric, and Tuscan orders which is below the annulets under the ovolo

Cementation is the process of converting iron into steel, which is done by stratifying bars of iron in

charcoal, igniting it, and letting them continue in a kiln in that state for five or six days: the carbon of the charcoal is thus absorbed by the iron, and the latter converted into steel

Cements, natural. When the proportion of clay in calcareous minerals exceeds 27 to 30 per cent., it is seldom that they can be converted into lime by calcination; but they then furnish a kind of natural cement, which may be employed in the same manner as plaster of Paris, by pulverizing it, and kneading it with a certain quantity of water.

There are some natural cements which do not set in water for many days, and some which harden in less than a quarter of an hour: these last are the only ones which have been made use of at present. Though very useful in circumstances where a quick solidification is indispensable, they are far from affording, in ordinary cases, the advantages of hydraulic mortars or cements of good quality. In fact, they merely adhere to the stone, owing to the roughness of its surface, and the entanglement resulting from it; and, however dexterous or experienced the workman may be who makes use of them, he will be unable to connect the different parts of his masonry in one continuous bond by means of them. This statement must be understood to apply only to cements which harden while in contact with bricks *under water*, because the adhesion of such as dry in the open air is well known to be much greater than what would be caused merely by asperities of the surface. It is not uncommon to see from twenty to thirty bricks stuck to one another by Roman cement, and projecting at right angles from the side of a wall, as a proof of the excellence of the composition; and an instance has been mentioned in which thirty-three bricks were successfully supported in this manner. Now, if we assume the weight of a brick and its corresponding joint of cement to be 6 lbs., and their thickness, when the bricks were joined one to another in the manner above alluded to (in which the longest dimension of the brick was placed vertically), to be 2½ inches, then the cohesive force necessary to unite the first brick to the wall, with sufficient firmness to bear the strain occasioned by the weight of the remaining thirty-two supported by it, must have been nearly 91 lbs. per square inch, or equivalent to a direct load of 3640 lbs. upon its whole surface of about 40 square inches.

That which is in England very improperly termed Roman cement is nothing more than a natural cement, resulting from a slight calcination of a calcareous mineral, containing about 31 per cent. of ochreous clay, and a few hundredths of carbonate of magnesia and manganese. A very great consumption of this cement takes place in London; but its use will infallibly become restricted, in proportion as the mortars of eminently hydraulic lime shall become better known, and, in consequence, better appreciated.

Very recently, natural cements have been found in Russia and in France. They may be composed at once by properly calcining mixtures made in the average proportions of 66 parts of ochreous clay to 100 parts of chalk. It is fair, however, to admit, that no artificial product has yet been proved to equal the English cement in point of hardness.

The pure calcareous substances, when imperfectly calcined, become converted into sub-carbonates, possessed of certain properties. These properties are to afford a powder, which, when kneaded with water in the same way as plaster of Paris, acquires in it, at

first, a consistency more or less firm, but which does not continue its progress at the same rate.

The argillaceous limestones, and the artificial mixtures of pure lime and clay in the proportions requisite to constitute hydraulic lime by the ordinary calcination, become natural or artificial cements when they have been subjected merely to a simple incandescence, kept up for some hours, or even for some minutes. This result, which has often occurred in the course of first experiments in burning the artificial hydraulic limestones, has been equally observed in Russia by Colonel Raucourt; and M. Lacordaire, Engineer of Roads, has not only fully verified it with respect to the different argillaceous limestones of the neighbourhood of Pouilly, but has also made a useful and happy application of it in the works which have been erected at the junction of the Burgundy canal; both in transforming these limestones into natural cements, and in turning to account the large quantity of half-burnt lime which is found in the upper layers of the kilns, when the intensity and duration of the heat is so regulated as not to exceed the limit proper for the lower strata of the charge.

The history of these new cements will not be complete until authentic and multiplied experiments shall have established their power to resist the effects of air and frost, and the degree of adhesion with which they unite to the building-stone

Cenotaphium, a cenotaph, an empty or honorary tomb, erected by the Greeks as a memorial of a person whose body was buried elsewhere, or not found for burial

Censitores, surveyors of the Roman aqueducts

Centaur, poetically, and in ancient mythology, a being represented as half man, half horse; the Sagittarius of the Zodiac

Centering, temporary suppo cipally of timber, placed an under vaults and arches t them while they are in c building. Much ingenuit played in the centering fo and tunnels

Centigrade, the division int or degrees by hundredtl called alto centesimals

Central forces, the power cause a moving body to wards or recede from the motion. When a body to revolve in a circle rou fixed point, it will have a c tendency to fly off in a stra at a tangent in the circl tendency is called the *ce force;* and the opposing which the body is retaine circular path is called th *petal force*

Centre, any timber frame, frames, for supporting tl stones of a bridge during struction of an arch.

The qualities of a goo consist in its being a suffic port for the weight or pre the arch-stones, without sible change of form taki throughout the whole pro the work, from the spri the arch to the fixing of stone: it should be capable easily and safely removed, signed so that it may be e a comparatively small exp

In navigable rivers, whe tain space must be left for sage of vessels, and in d rapid rivers, where it is di establish intermediate and where much is to b hended from sudden flo frames should span the wh of the archway, or be fran to leave a considerable p the archway unoccupied. cases, a considerable degr is required to make the effectual support for tl stones, particularly when

is large. But in narrow rivers, and in those where the above-mentioned inconveniences do not interfere with the work, the framing may be constructed upon horizontal tie-beams, supported in several places by piles, or frames fixed in the bed of the river; and the construction is comparatively easy.

In large arches, when the arch-stones are laid to a considerable height, they often force the centre out of form, by causing it to rise at the crown; and it is sometimes necessary to load the centre at the crown to prevent such rising; but this is a very imperfect remedy. Notwithstanding the subject has been considered by several very eminent men, their works are not much calculated to instruct the carpenter how to avoid this difficulty: indeed, their object seems to have been exclusively to calculate the strength of a centre already designed, instead of showing the principles on which it ought to be contrived; and even in calculating the strength, they are very imperfect guides, because they have not attempted to find what forces would derange a centre, but only the force that might be supported without fracture.

Centre, in a general sense, denotes a point equally remote from the extremes of a line, surface, or solid: the word signifies a point

Centre-bit, in joinery, an instrument with a projecting conical point nearly in the middle, called the centre of the bit: on the narrow vertical surface, the one most remote from the centre, is a tooth with a cutting edge. The under edge of the bit on the other side of the centre has a projecting edge inclined forward. The horizontal section of this bit upwards is a rectangle. The axis of the small cone in the centre is in the same straight line as that of the stock; the cutting edge of the tooth is more prominent than the projecting edge on the other side of the centre, and the vertex of the conic centre is still more prominent than the cutting edge of the tooth.

The use of the centre-bit is to form a cylindric excavation, having the upper point of the axis of the intended hole given on the surface of the wood. The centre of the bit is first fixed in this point; then, by placing the axis of the stock and bit in the axis of the hole intended to be bored, with the head of the stock against the breast, and by turning the stock swiftly round by means of the handle, the hollow cone made by the centre will cause the point of the tooth to move in the circumference of a circle, and cut the cylindric surface progressively as it is turned round, while the projecting edge upon the other side of the centre will cut out the cone in a spiral-formed shaving. Centre-bits are of various sizes, for bores of different diameters.

Centre-chuck, a chuck which can be screwed on the mandril of a lathe, and has a hardened steel core or centre fixed in it; also a projecting arm or driver

Centre-drill, a small drill used for making a short hole in the ends of a shaft about to be turned, for the entrance of the lathe centres

Centre of attraction of a body is that point into which, if all its matter were collected, its action upon any remote particle would still be the same as it is while the body retains its own proper form; or it is that point to which bodies tend by their own gravity, or about which a planet revolves as a centre, being attracted or impelled towards it by the action of gravity. The common centre of attraction of two or more bodies is used to denote that point in which, if a particle of matter were placed, the action of each body upon it would be equal, and where it will remain in equilibrium, having no tendency to move one way rather than another

Centre of a circle, that point in a circle which is equally distant from every point of the circumference, being that from which the circle is described

Centre of a conic section, that point which bisects any diameter, or that point in which all the diameters intersect each other. This point in an ellipse is within the figure, in the hyperbola without, and in the parabola it is at an infinite distance

Centre of conversion, a mechanical term, the signification of which may be thus conceived: if a stick be laid on stagnant water, and drawn by a thread fastened to it, so that the thread makes always the same angle with it, the stick will be found to turn about a certain point; which point is called the 'centre of conversion'

Centre of a curve of the higher kind, is the point where two diameters concur; and when all the diameters concur in the same point, it is called the general centre

Centre of a dial, that point where the gnomon or style, placed parallel to the axis of the earth, intersects the plane of the dial

Centre of an equilibrium is the same with respect to bodies immersed in a fluid as the centre of gravity is to bodies in free space, or it is a certain point on which, if a body, or system of bodies, be suspended, they will rest in any position

Centre of friction is that point in the base of a body on which it revolves, in which, if the whole surface of the base and the mass of the body were collected and made to revolve about the centre of the base of the given body, the angular velocity destroyed by its friction would be equal to the angular velocity destroyed in the given body by its friction in the same time

Centre of gravity of any body, or system of bodies, is that point upon which the body or system of bodies *acted upon only* by the force of gravity will balance itself in all positions; or it is a point on which, when supported, the body or system will be supported, however it may be situated in other respects. Hence it follows, that if a line or plane passing through the centre of gravity be supported, the body or system will also be supported; and conversely, if a body or system balance itself upon a line or plane, in all positions, the centre of gravity is in that line or plane. In a similar manner it will appear, that if a body rest in equilibrio when suspended from any point, the centre of gravity of that body or system is in the perpendicular let fall from the centre of suspension; and on these principles depends the mechanical method of finding the centre of gravity of bodies

Centre of gyration, that point in a body revolving on an axis, into which, if the matter of the whole body were collected, the same angular velocity would be generated by the same moving force

Centre of motion of a body is a fixed point about which the body is moved; and the axis of motion is the fixed axis about which it moves

Centre of oscillation, the point in which the whole of the matter must be collected, in order that the time of oscillation may be the same as when it is distributed

Centre of percussion, that point of a revolving body which would strike an obstacle with the same force as if the whole of the matter were collected in it

Centre of position, in mechanics, denotes a point of any body, or system of bodies, so selected that we may properly estimate the situation and motion of the body or system by those points

Centre of pressure, or meta centre of a fluid against a plane, is that point against which a force being applied, equal and contrary to the whole pressure, it will sustain it, so as that the body pressed on will not

to either side. This is the
ıs the centre of percussion,
ing the axis of motion to be
intersection of this plane
he surface of the fluid; and
ıtre of pressure upon a plane
l to the horizon, or upon any
vhere the pressure is uniform,
same as the centre of gravity
; plane

f spontaneous rotation, that
which remains at rest the in-
a body is struck, or about
the body begins to revolve.
ıdy of any size or form, after
y or gyratory motions, be
tirely to itself, it will always
hree principal axes of rota-
hat is, all the rotary motions
ch it is effected may be con-
' reduced to three, which are
ned round three axes per-
ular to each other, passing
h the centre of gravity, and
, preserving the same position
olute space, while the centre
rity is at rest, or moves uni-
forward in a right line

honic, in acoustics, the place
the speaker stands in making
llabical and articulate echoes

honocamptic, the place or
which returns the voice

unch, a small piece of steel
a hardened point at one

in turnery, are the two cones
heir axes horizontally posited
staining the body while it is
l

elic or *Velic-point*, the centre
vity of an equivalent sail, or
ngle sail whose position and
tude are such as cause it to
ed upon by the wind when
essel is sailing, so that the
ı shall be the same as that
takes place while the sails
heir usual positions

gal force is that force by
a body revolving about a
, or about another body, has
ency to recede from it

gal pump, a machine for raising water by centrifugal force combined with the pressure of the atmosphere

Centripetal force is that force by which a body is perpetually urged onwards to a centre, and thereby made to revolve in a curve instead of a right line

Cerium, a metal discovered in 1803 by Berzelius, and named after the planet Ceres. It is brittle, white, and volatile in a very intense heat: it is not acted upon by nitric acid, but is dissolved in aqua regia, nitro-hydrochloric acid

Chain, in surveying, is a lineal measure, consisting of a certain number of iron links, usually 100, serving to take the dimensions of fields, &c.: at every tenth link is usually fastened a small brass plate, with a figure engraved upon it, or else cut into different shapes, to show how many links it is from one end of the chain

Chains, strong links or plates of iron, the lower ends of which are bolted through a ship's side to the timbers

Chain-plates, plates of iron bolted to the side of a ship, to which the chains and dead-eyes of the lower rigging are connected

Chain-pump, an hydraulic machine for raising water. It is made of different lengths, and consists of two collateral square barrels and an endless chain of pistons of the same form, fixed at proper distances

Chain-timber, in brick-building, a timber of large dimensions placed in the middle of the height of a story, for imparting strength

Chairs. Anciently, in most apartments we find "two great chayers:" these were arm-chairs, with stuffed backs and sides, entirely covered, and similar to the lounging-chairs of the present day. Others are described as 'Flemish chairs,' 'scrolled chairs,' and 'turned chairs,' wrought in ebony, walnut, cherry-tree, &c., with high backs, either stuffed in

one long upright panel, or filled with wicker-work, &c.

Chalcedony, a precious stone, in colour like a carbuncle; by some translated from the Scriptures as 'emerald'

Chalcidicum, among the Romans, a large, low, and deep porch, covered with its own roof, supported on pilasters, and appended to the entrance-front of a building, where it protected the principal doorway, and formed a grand entrance to the whole edifice

Chalcidria, chambers attached to a basilica; they were built at one end when the situation would admit of it

Chalice, the cup used for the wine at the celebration of the Eucharist

Chalk, in geology, forms the higher part of the series or group termed cretaceous: it is composed of nearly 44 parts of carbonic acid and 56 parts of lime

Chambers, according to Palladio, are made either arched or with a flat ceiling: if in the last way, the height from the floor to the joists above ought to be equal to their breadth; and the chambers of the second story must be a sixth part less than them in height

Chamfer. An edge or arris, taken off equally on the two sides which form it, leaves what is called a chamfer, or a chamfered edge. If the arris be taken off more on one side than the other, it is said to be splayed or bevelled

Chamfering, the process of cutting the edge or the end of any thing bevel or aslope

Champ, the flat surface of a wall

Champe, the field or ground on which carving is raised

Champ de Mars: in French history, the public assemblies of the Franks are said to have been held in an open field, and in the month of March; whence the name

Chancel, the choir or eastern part of a church appropriated to the use of those who officiate in the performance of the services, and separated from the nave and other portions in which the congregation assemble, sometimes by a screen

Channel, in hydrography, the deepest part of a river, harbour, or strait, which is most convenient for the track of shipping; also an arm of the sea running between an island and the main, or continent, as the British Channel, &c.

Channels, broad pieces of plank bolted edgewise to the outside of a vessel, used for spreading the lower rigging

Chant, *Chanting*. The word 'chant' is derived from the Latin *Cantus*, which signifies singing; a song, a tune, or melody,—the sound of a trumpet, crowing of a cock (whence this bird is called 'chanticleer'): it also signifies the frequent repetition of the same thing. The word chant is not confined to merely a melody consisting of several notes; it may consist of one only: in this case it is called, in church music, 'intonation,' although in Gregorian music the word intonation has a somewhat different signification. (See *Gregorian Chant*.) Hence chanting is reciting in a musical tone, and is peculiarly adapted to a dignified utterance of the sublime language of the Liturgy. Chanting or intoning on a monotone, or single sound, is the simplest and easist method of reading and responding the various prayers, exhortations, litanies, suffrages, Kyrie eliesons, Allelujahs, Gloria Patri, and the Amens, and is eminently more dignified and solemn than when there is neither elevation nor depression of the voice at any one termination. In chanting the greater and lesser Canticles,—the Te Deum, Jubilate, Benedicite, Benedictus, Athanasian Creed, Venite exultemus, Magnificat, Cantate Domino, Nunc dimittis, Deus misereatur, as also the prose Psalms, —the chant may consist of more than one tone, although it is preferable to use a small number. The method of chanting the Psalter in

the English church is different from that adopted on the Continent, where it appears to be governed by no rule; whereas the Gregorian chant is governed entirely by rule

Chantlate, in building, a piece of wood fastened near the ends of the rafters, and projecting beyond the wall, to support two or three rows of tiles, so placed to hinder the rain-water from trickling down the sides of the walls

Chantry, an ecclesiastical benefice or endowment to provide for the chanting of masses

Chapel, a small building attached anciently to various parts of large churches or cathedrals, and separately dedicated; also a detached building for divine service: in England, chapels are sometimes called *chapels of ease*, built for the accommodation of an increasing population

Chapelling, wearing a ship round, when taken aback, without bracing the head-yards

Chapiter, the capital of a column

Chaplet, in architecture, a small ornament carved into round beads, &c.

Chaps, the two planes or flat parts of a vice or pair of tongs or pliers, for holding any thing fast, and which are generally roughed with teeth

Chapter-house, an establishment for Deans and Prebendaries of cathedrals and collegiate churches; the apartment or hall in which the monks and canons of a monastic establishment conduct their affairs connected with ecclesiastical regulations

Char or *Chare*, to hew, to work charred stone; hewn stone

Character, in a picture, is giving to the different objects their appropriate and distinguishing appearance

Charcoal consists mainly of carbon procured from the decomposition of wood by burning. This operation is generally conducted in pits made in the ground, and in iron cylinders. Wood is essentially composed of carbon, oxygen, and hydrogen. Charcoal has the same properties: it is black, lighter than water, and full of pores, occasioned by the expulsion of the bodies volatilized

Charge, in electricity, is the accumulation of the electric matter on one surface of an electric, as a pane of glass, Leyden phial, &c., whilst an equal quantity passes off from the opposite surface

Charge, in mining: any quantity of ore put at one time into a furnace to fuse is called a 'charge;' letting it out is called 'tapping'

Chargers, large dishes, sometimes described as 'flat pieces'

Cheeks, the shears or bed of the lathe as made with two pieces for conducting the puppets

Cheeks, the projection on each side of a mast, upon which the trestle-trees rest; the sides of the sheet of a block

Cheerly, quickly; with a will

Chemistry. The science of chemistry has for its object the study of the nature and properties of the different substances of which the earth, the waters, the air, and their inhabitants, (namely, plants and animals,) are composed. In a word, it embraces the study of every thing under heaven accessible to man. In its highest branches it aims at discovering the laws or rules which regulate the formation of chemical compounds generally; and in its useful applications it has been already exceedingly serviceable in directing and improving the various arts of common life, as agriculture, the working of metals, dyeing, and many other pursuits. It serves also to guide the medical man in the preparation of his remedies, and also occasionally in distinguishing between diseases which are in other respects much alike. There is, indeed, scarcely a situation in life in which a knowledge of chemistry may not prove directly useful. It is a science the study of which, from its simplest

beginnings to its highest attempts, is rendered delightful by the constant succession of new and interesting things brought before the eye and the mind.

Cherry-tree, a hard, close-grained wood, of a pale red-brown colour: when stained with lime, and oiled and varnished, it resembles mahogany, and is used for furniture, &c.

Chess-trees, pieces of oak fitted to the sides of a vessel, abaft the fore-chains, with a sheave in them, to board the main-tack to; not much used

Chest, a piece of furniture for the reception of all kinds of goods, particularly household conveniences, deposited therein for security, and for plate; placed also in churches, for the keeping of the holy vessels, vestments, &c.: the seaman's chest contains all the personalities of a sailor.

Coffers and chests were the general repositories for articles of every kind; writings, apparel, food, and even fuel, were kept within them. Many of these chests, which were raised on feet to protect them from damp and vermin, were beautifully ornamented with carving and other sumptuous enrichments. Large trunks, in which clothes, hangings, &c., were packed for removal, were called 'Trussing Chests:' they were substantially made, and bound in every direction with iron straps, wrought into fanciful forms, and secured by locks of artful and curious contrivance. Two "standard chests" were delivered to the laundress of King Henry VIII.; "the one to keep the cleane stuff, and the other to keep the stuff that had been occupied." "In ivory coffers," says Grameo, "I have stuffed my crowns; in cypress chests, my arras, counter-points, &c." Cypress wood was selected for its rare properties of neither rotting nor becoming worm-eaten.

Chestnut wood is very durable, and was formerly much used in house *carpentry and furniture*

Cheval de frise, a square or octagonal beam of wood, from 6 to 9 feet in length, and pierced by iron rods or wooden pickets 6 feet long, which are pointed at each end, and shod with iron: the pickets are placed 6 inches asunder, and pass through two opposite faces of the beam, in directions alternately at right angles to each other, the cheval resting on the ground at the lower extremity of the pickets

Chevet, the termination of a church behind the high altar, when of a semicircular or polygonal form

Chevron, a moulding of a zig-zag character, of the Norman style particularly, but sometimes to be found with the pointed arch

Chiaro-oscuro, a drawing made in two colours, black and white; also the art of advantageously distributing the lights and shadows which ought to appear in a picture, as well for the repose and satisfaction of the eye as for the effect of the whole together

Chiliad, an assemblage of several things ranged by thousands; applied also to tables of logarithms, which were at first divided into thousands

Chiliaëdron, a solid figure of a thousand faces

Chiliagon, in geometry, a regular plane figure of a thousand sides and angles

Chimes, a set of bells tuned to the modern musical scale, and struck by hammers acted on by a pinned cylinder, or barrel, which revolves by means of clock-work: also applied to the music or tune produced by mechanical means from the bells in a steeple, tower, or common clock

Chimney, in locomotive engines. The chimney is regulated in size for each engine so as to act in union with the blast-pipe, to produce a proper blast on the fire. This is done by each exhaust of steam from the cylinders creating a partial vacuum in the chimney: hence a

rush of air takes place through the fire and tubes to fill this vacuum; and these successive rushes of air 'blow the fire.' This vacuum ranges from 2 to 8 inches of a water-gauge. The mild blast produces the least vacuum and the least consumption of fuel

Chimney-pieces. The Egyptians, the Greeks, and the Romans, to whom architecture is so much indebted in other respects, living in warm climates, where fires in the apartments were seldom necessary, have thrown but little light on this branch of the science. Palladio only mentions two which stood in the middle of the rooms, and consisted of columns, supporting architraves, whereon were placed the pyramids or funnels through which the smoke was conveyed. Scamozzi mentions only three in his time, placed similarly. In England, Inigo Jones designed some very elaborate chimney-pieces. The size of the chimney must depend upon the dimensions of the room wherein it is placed: the chimney should always be situated so as to be immediately seen by those who enter: the middle of the side partition wall is the best place in halls, saloons, and other rooms of passage to which the principal entrances are commonly in the middle of the front or of the back wall; but in drawing-rooms, dressing-rooms, &c., the middle of the back wall is the best situation; the chimney being then farthest removed from the doors of communication

Chinese architecture, a style peculiar to China, where the material employed is principally wood. It is a style not congenial to English taste or climate: its monstrosity may be seen at Brighton

Chinese Yellow (colour), a very bright sulphuret of arsenic, brought from China

Chinse, to thrust oakum into seams with a small iron

Chisel, a tool with the lower part in the form of a wedge, for cutting iron plate or bar, and with the upper part flat, to receive the blows of a hammer, in order to force the cutting edge through the substance of the iron

Chisel, an instrument used by carpenters. The large chisels used by millwrights for heavy work are generally composed of iron and steel welded together. Chisels are also employed in turning, and they are driven more or less by blows: those used by the joiner are similar; but those used by cabinet-makers are straight across the end

Chisels in general. A chisel is an edge tool for cutting wood, either by leaning on it or by striking it with a mallet. The lower part of the chisel is the frustrum of a cuneus or wedge; the cutting edge is always on and generally at right angles to the side. The basil is ground entirely from one side. The two sides taper in a small degree upwards, but the two narrow surfaces taper downwards in a greater degree. The upper part of the iron has a shoulder, which is a plane surface at right angles to the middle line of the chisel. From this plane surface rises a prong in the form of a square pyramid, the middle line of which is the same as the middle line of the cuneus or wedge: the prong is inserted and fixed in a socket of a piece of wood of the same form: this piece of wood is called the handle, and is generally the frustrum of an octagonal pyramid, the middle line of which is the same as that of the chisel: the tapering sides of the handle diminish downwards, and terminate upwards in an octagonal dome. The use of the shoulder is for preventing the prong from splitting the handle while being struck with the mallet. The chisel is made stronger from the cutting edge to the shoulder, as it is sometimes used as a lever, the prop being at or very near the middle,

the power at the handle, and the resistance at the cutting-edge. Some chisels are made with iron on one side and steel on the other, and others consist entirely of steel. There are several kinds of chisels, as the mortise-chisel, the ripping-chisel, and the socket-chisel

Chisel, the firmer, is formed in the lower part similar to the socket-chisel; but each of the edges above the prismoidal part falls into an equal concavity, and diminishes upwards until the substance of the metal between the concave narrow surfaces becomes equal in thickness to the substance of that between the other two sides, produced in a straight line, and meeting a protuberance projecting equally on each side. The firmer chisel is used by carpenters and joiners in cutting away the superfluous wood by thin chips: the best are made of cast steel. When there is a great deal of superfluous wood to be cut away, sometimes a stronger chisel, consisting of an iron back and steel face, is first used, by driving it into the wood with a mallet; and then a slighter one, consisting entirely of steel sharpened to a very fine edge, is used in the finish. The first used is called a firmer, and the last a paring chisel, in the application of which only the shoulder or hand is employed in forcing it into the wood

Chisel, the mortise, is made exceedingly strong, for cutting out a rectangular prismatic cavity across the fibres, quite through or very deep in a piece of wood, for the purpose of inserting a rectangular pin of the same form on the end of another piece, and thereby uniting the two. The cavity is called a mortise, and the pin inserted, a tenon; and the chisel used for cutting out the cavity is, therefore, called a mortise-chisel. As the thickness of this chisel from the face to the back is great, in order to withstand the percussive force of the mallet, and as the angle which the basil makes with the face is about 25°, the slant dimension of the basil is very great. This chisel is only used by percussive force given by the mallet

Chisel, the ripping, is only an old socket-chisel used in cutting holes in walls for inserting plugs, and for separating wood that has been nailed together, &c.

Chisel, the socket, is used for cutting excavations: the lower part is a prismoid, the sides of which taper in a small degree upwards, and the edges considerably downwards: one side consists of steel, and the other of iron. The under end is ground into the form of a wedge, forming the basil on the iron side, and the cutting edge on the lower end of the steel face. From the upper end of the prismoidal part rises the frustrum of a hollow cone, increasing in diameter upwards: the cavity or socket contains a handle of wood of the same conic form: the axis of the handle, the hollow cone, and the middle line of the frustrum, are all in the same straight line. The socket-chisel, which is commonly about 1¼ or 1½ inch broad, is chiefly used in cutting mortises, and may be said to be the same as the mortise-chisel employed in joinery

Chisel, in turnery, a flat tool, skewed in a small degree at the end, and bevelled from each side, so as to make the cutting edge in the middle of its thickness

Chock, in navigation, a wedge used to secure any thing with, or for any thing to rest upon. The long-boat rests upon two large chocks when it is stowed

Chocolate lead, a pigment prepared by calcinating oxide of lead with about a third of that of copper, and reducing the compound to a uniform tint by levigation

Choke. An adit is said to be choked when any earth or stone falls in and prevents the current of water

through it: the place or part so filled is called 'the choke'

Chopping block, a block of wood used for reducing bricks to their intended form by axing them: it is made of any chance piece that can be obtained, and commonly from 6 to 8 inches square, supported generally upon two 14-inch brick piers, if two men are to work at it; but if four men, the chopping-block must be lengthened and supported by three piers, and so on, according to the number: it is about 2 feet 3 inches in height

Choragic monuments, in Grecian story, monuments in honour of those who had gained a prize as choragus, or leader of the play and choruses

Choragic monument (the) of Lysicrates, known as the Lantern of Demosthenes, was built in the 111th Olympiad, and is still entire: it is considered the most exquisite and perfect specimen of the orders

Choragic monument of Thrasycles, &c., now the church of our Lady of the Grotto. It is built against the rock of the Acropolis: above it stand two columns, on which tripods have been placed, and on each side of it the rock has been chiseled away in such form as evidently shows that similar buildings had been erected contiguous to it

Chord, in geometry, is the right line joining the extremities of any arc of a circle

Chorobates (Greek), an instrument for determining the slope of an aqueduct, and the levels of the country through which it was to pass. It differed but slightly from a common carpenter's level, which consists of a straight rule supporting a perpendicular piece, against which hangs a plumb-line

Chorography, the art of making a map of a particular country or province, or of teaching geography

Chromatics, a division of the science of optics, by which the properties of the colours of light and of natural bodies are illustrated

Chromascope, or optical chromatics: there are three species of optical effects of colours,—that of refraction of prisms and lenses, that of the transmission of light through transparent media, and that of the reflection of specula, &c.

Chromate of mercury is improperly classed as a red with vermillion; for though it is of a bright ochreous red colour in powder, it is, when ground, of a bright orange ochre hue, and affords, with white, very pure orange-coloured tints

Chromatics, the science of the relations of light, shade, and colours

Chrome greens are compound pigments of which chrome yellow is the principal colouring substance

Chrome orange is a beautiful orange pigment, and one of the most durable and least exceptionable chromates of lead, but not of iron

Chrome yellow is a pigment of modern introduction into general use, and of which there are many varieties, mostly chromates of lead, in which the latter metal more or less abounds. They are distinguished by the pureness, beauty, and brilliancy of their colours, which qualities are great temptations to their use in the hands of the painter; they are, however, far from unexceptionable pigments

Chromium, a very rare metal, found either in the form of chromate of lead or chromate of iron

Chronometer, a time-keeper, used for determining the longitude at sea, and for other purposes where great accuracy is required

Chronometrical governor, an improved regulator for rendering the mean velocity of an engine uniform. The mechanism is as follows: a spindle placed vertically has a pulley fixed upon the top, to receive motion from the crank-shaft; below the pulley two bevel-wheels of equal diameters are placed face to face; the upper wheel is fixed to the spindle, and the lower one is free to turn upon it, and has an arm or crank attached

to its under side, to act as a driver for the pendulous ball: between the two wheels, and communicating with them, is a third wheel, fixed upon a spindle placed horizontally, and connected at one end to the vertical spindle, so as to turn round it; the other end is supported by a carriage resting upon a plate, and is connected to a spring or counterweight on one side, and on the other side to the throttle-valve; the ball being suspended from a spherical bearing near the top of the rod. The spring is adjusted so that when the velocity of the engine is as required, the upper and lower wheels revolve at the same speed: when the velocity increases, the centrifugal force causes the ball to rise, and retards the motion of the lower wheel; then the intermediate wheel distends the spring, and moves forward upon the lower wheel as a rack, and closes the throttle-valve: when the velocity diminishes, the ball falls, and the lower wheel requires less power, so that the spring pulls back the intermediate wheel and opens the valve. The above is a modification of Mr. James Wood's governor, and is patented by Mr. C. W. Siemans

Chrysolite, a precious stone, probably the tenth on the high priest's pectoral, bearing the name of Zebulon: it is transparent, the colour of gold, with a mixture of green, which displays a fine lustre

Chuck, a piece of wood or metal fixed on the end of the mandril for keeping fast the body to be turned

Church Music. By this term is commonly understood *all* music set to words of a sacred character: hence we have not only the language of Scripture set to music in the shape of anthems, &c., but also metrical versions and paraphrases thereof, used and considered by many as church music. Indeed it too often happens that these are *adapted* to *secular* melodies—melodies not originally intended to be applied to words of a sacred character, the music is then termed probably from an idea that t no such thing as sacred and music. But this is a grea and arises solely from ignor the existence of sacred musi mean especially church musi amine any of the ancient aut liturgical books, and there found an order of music th not be mistaken for profane is not only sacred in its ch but eminently grand, di noble, and sublime; in sho for church purposes so sup all other music, that it alo properly be called church m

Church music is the musi holy offices,—is that music i the *whole church*, priests and can participate. It is easy cute, being simple and plain chant). It can be sung b one, and is always most n when sung by all; hence it called the full chant (cant nus). For a long period, an very lately, scarcely a rem church music was to be foun in those places where we right to expect to find it: th chant was banished entirely i places, and mutilated in oth that it could scarcely be dis but it is now being restore we hear the priest intoning l in the offices of morning and e prayer, and the people sing response, the ancient aut melodies of the church;—w the Psalter chanted to fine called) Gregorian tones;—w the Litany chanted to its own music, that of the church: hear the soul-stirring music Communion office, the Glori celsis, the Credo, and Sanct latter moreover in its prope We can have also, if so di the church music for the monial, baptismal, and burial as well as an immense var tunes for the metrical psalm

true church character, unlike any other kind of music, and which is truly church music, inasmuch as it is the church's peculiar property, and would be totally misused in any other place. Our definition of church music is, music which is adapted for the services and purposes of the church, and unfit for any other place or purpose.

Church music, such as is here shortly defined, is unisonous; and harmonized music is not fit for congregational purposes; it is proper only in those parts of divine worship which may be called extra-liturgical, such as the anthem. Singing harmonized chants, canticles, Te Deum, &c., is thrusting out the congregation, that is, the chief part of the church present. The harmonies should be left entirely to the discretion of an intelligent organist, to be executed on the organ alone. Harmonized music requires accomplished and well-informed musicians for its performance, and can be sung only by the few. The anthem, in cathedral worship, is edifying only when it is performed by the choir-men in a masterly manner, not only with correct musical execution, but with care and attention, to develop all the piety, sublimity, grandeur, dignity, and whatever else the music is capable of.

Before the latter half of the 15th century, the liturgy was chanted in unison; and it is from this period we can trace the gradual departure from the rigid church style of music, in the compositions of Josquin de Près especially. In the early part of the 16th century, we find that Adrian Willært, who was made singing-master at St. Mark's, Venice, was the first who harmonized the psalm melodies for two or more choirs; then followed the motet, or harmonized antiphon, which before had been chanted in unison, as it is done at this day in the Romish chapels in England, where there are not accomplished singing men to perform the motet. During this century, the use of harmony had not only driven the people away from their part in the performance of the service, but also corrupted the music itself so much, that it was only saved from being wholly forbidden by the grave and devotional motets and other compositions of the renowned Palestrina, whose works were imitated with great success by the disciples of his school, and this in a very eminent degree by the English church musicians. The harmonies used by Tallis, Morley, Gibbons, and the rest of the masters of church music of this age, are truly sublime

Church ornament consists principally of the painted and stained glass windows of the emblem of the Trinity, of the passion of our Lord, of the evangelists, sacred monograms, statues of the holy apostles, of the holy evangelists, and of the saints commemorated by the church

Church in rotundo, that whose plan is a perfect circle, in imitation of the Pantheon

Chymol, a hinge, anciently called a grimmer

Ciborium, an arch supported by four pillars placed over the high altar

Cilery, in architecture, the drapery or leavage that is wrought upon the heads of pillars

Cimellare, the vestry or room where plate, vestments, and other rich things belonging to the church are kept

Cincture, a ring, list, or fillet at the top and bottom of a column, serving to divide the shaft from the capital and its base

Cinder-frame, in locomotive engines, a wire-work frame placed in front of the tubes, to arrest the ascent of large pieces of ignited coke

Cinque-foil, an ornamental foliation or feathering, used in the arches of the lights and tracery of windows, panellings, &c.

Cinque Ports, the sea-port towns of

Dover, Sandwich, Hastings, Hythe, and Romney, to which three others were afterwards added, viz. Winchelsea, Rye, and Seaford. These towns possess peculiar privileges, and are under the government of a Lord Warden

Cipher, a secret mode of writing

Cippus (Latin), a low column, sometimes round, but more frequently rectangular, used as a sepulchral monument

Circinus, a pair of compasses. Those used by statuaries, architects, masons, carpenters, &c., were often represented on their tombs

Circinus, according to Vitruvius, a pair of compasses employed by architects, carpenters, &c., for describing circles, measuring distances, and taking the thickness of solids

Circle, a plain figure contained by one line, which is called the circumference, and is such that all straight lines drawn from a certain point within the figure to the circumference are equal to one another, and this point is called the centre of the circle

The circumference of a circle is known to be about 3·14159 times its diameter, or, in other words, the ratio of the circumference to the diameter is represented by 3·14159: for this number writers generally put the Greek letter π

Circular saw. Circular saws, revolving upon an axis, have the advantage that they act continually in the same direction, and no force is lost by a backward stroke: they are also susceptible of much greater velocity than the reciprocating saws, an advantage which enables them to cut more smoothly: used principally for cutting mahogany for veneering, and for other woods cut into thin layers

Circus, an area used by the Romans for chariot-races and horse-races, and for other public sports

Cissoid of Diocles, in the higher geometry, a curve line of the second order

Cistern. There were cisterns throughout Palestine, in cities and in private houses. As the cities were mostly built on mountains, and the rains fall in Judea at two seasons only (spring and autumn), people were obliged to keep water in vessels. There are cisterns of very large dimensions at this day in Palestine. Near Bethlehem are the cisterns or pools of Solomon: they are three in number, situated in the sloping hollow of a mountain, one above another, so that the waters of the uppermost descend into the second, and those of the second descend into the third. The breadth is nearly the same in all, between 80 and 90 paces, but the length varies: the first is about 160 paces long; the second, 200; the third, 220. These pools formerly supplied the town of Bethlehem and the city of Jerusalem with water. Wells and cisterns, fountains and springs, are seldom correctly described in Scripture

Cistern, in the steam engine, the vessel which surrounds the condenser, and contains the injection water

Cisterna, an artificial tank or reservoir, sunk in the ground and covered in with a roof, for the purpose of collecting and preserving good water for the use of a household. Near the baths of Titus are nine subterraneous cisterns, 17½ feet wide, 12 feet high, and above 137 feet long

Citrine, or the colour of the citron, is the first of the tertiary class of colours, or ultimate compounds of the primary triad, yellow, red, and blue, in which yellow is the archeus or predominating colour, and blue the extreme subordinate; for citrine being an immediate compound of the secondaries, orange and green, of both which yellow is a constituent, the latter colour is of double occurrence therein, while the other two primaries enter singly into the composition of citrine; its mean or middle hue comprehending eight blue, five red, and six yellow, of equal intensities

Citrine lake is a durable and better drying species of brown pink, prepared from the quercitron bark

Clack, the valve of a pump piston; the can-lead, in Derbyshire

Clacks, in locomotive engines, the complete valves of the pumps where the ball-valve is enclosed in a frame or cage, to limit its rise, and guide its fall into the steam-tight seat of the orifice of the pipe

Clack-box, in locomotive engines, the box fitted on to the boiler where a ball-clack is placed, to close the orifice of the feed-pipe, and prevent steam or hot water reaching the pumps. The ball of the clack is raised from its seat by the stroke of the pump-plunger forcing the water against it, and which water then passes into the boiler, while the instant fall of the ball prevents egress from the boiler

Clack-door, a square iron plate screwed on to the side of a bottom-pump, or small bore for convenience of changing the clack or valve

Clack-seats, in locomotive engines, two recesses in each pump, for the clacks to fit into

Clack-valve, in the steam engine, a flat valve in the cold-water pump, with a hinge joint

Clamp, a kiln built above the ground, for the purpose of burning bricks in

Clamp, a piece of wood fixed to the end of a board by mortise and tenon, or by groove and tongue, so that the fibres of the one piece, thus fixed, traverse those of the board, and by this means prevent it from casting: the piece at the end is called a clamp, and the board is said to be clamped

Clamps, in naval architecture, thick planks in a ship's side, which support the ends of the beams

Clamping, in joinery: when a piece of board is fitted with the grain to the end of another piece of board across the grain, the first board is said to be clamped

Clamp-nails, used to fasten on clamps in the building of ships

Classic orders, in architecture: of these there are but *three*,—the Doric, Ionic, and Corinthian: two others, the Tuscan and Composite, are often improperly classed with them, and the whole denominated 'the five orders of architecture.' For the *proportions* of the respective orders, see the Synopsis, p. 26

Cleading, in locomotive engines, is usually made of narrow strips of timber, neatly fitted round the boiler and fire-box, to prevent the radiation of the heat. Externally, this is sometimes covered with zinc, and a coating of dry hair felt is commonly placed between the boiler and the timber, for the same purpose

Clearing the deads, a term for clearing a shaft or drift, &c.

Cleat, a piece of wood used in different parts of a vessel to belay ropes to

Cleavage, in geology, is an indicator of peculiar fossility in certain rocks, which is independent of, and meets at a considerable angle, the surfaces of lamination or deposition. Clay slate furnishes the best examples of this phenomenon

Cleithral, a covered Greek temple

Cleithros, an enclosed place; a temple whose roof covers or encloses it

Clerestory, an upper story or row of windows in a Gothic church, rising clear above the adjoining parts of the building

Clew, the lower corner of square-sails, and the after corner of a fore-and-aft sail

Clew-garnet, a rope for hauling up the clew of a fore-sail or main-sail in a square-rigged vessel

Clew-line, a rope for hauling up the clew of a square-sail: the clew-garnite is the clew-line of a course

Clicket, a latch-key; the latch of a door

Clinch, in navigation, the great ring connected with the mooring-chains

Clinch, a half-hitch stopped to its own part

Clinker-bar, in steam engines, the bar fixed across the top of the ash-pit for supporting the rods used for clearing the fire-bars

Clinkers, bricks which, by the violence of the fire, are run together and glazed over

Clinkers, hard bricks imported from Holland

Cloaca, a common sewer. The term cloaca is generally used in reference to those spacious subterraneous vaults, either of stone or brick, through which the foul waters of the city, as well as all the streams brought to Rome by the aqueducts, finally discharged themselves into the Tiber

Cloaca, according to Livy, a large subterraneous canal, constructed of masonry or brick-work, for the purpose of carrying off the rain-water from the streets of a town, and the impurities from private houses, which were thus discharged into some neighbouring river

Cloacarium, the sewers' rate; a tax which was levied in Rome for the expenses of cleansing and repairing the sewers

Cloister, a covered ambulatory, forming part of a monastic or collegiate establishment. Cloisters are always attached to a college cathedral, and arranged round three or four sides of a quadrangular area, with large windows, not often glazed, looking into the quadrangle

Close-hauled, a term applied to a vessel sailing with her yards braced up so as to get as much as possible to windward

Closer, a brick-back inserted where the distance will not permit of a brick in length

Closet, a small chamber or private room

Clove-hitch, two half-hitches round a spar or other rope

Clove-hook, an iron clasp, in two parts, moving upon the same pivot and overlapping one another, used for bending chain-sheets to the clews of sails

Clubbing, drifting down a current with an anchor out

Club-haul, to bring a vessel's head round on the other tack, by letting go the lee anchor, and cutting or slipping the cable

Clue-garnets, in navigation, tackles fixed to the clews or lower corners of the fore and main sail, to clew them up to the yards. (See *Clew-garnet*.)

Clustered column, a pier which consists of several columns or shafts clustered together

Clutch, an apparatus for engaging or disengaging two shafts: it consists of two pieces of metal formed so that when placed together, projecting pieces on one (which is made to slide to and fro on the shaft, but turn with it) fit into recesses in the other, which is fixed on the driving shaft, so that the first being pulled back, its shaft will remain at rest

Coaking, in ship-building, uniting pieces of spar by means of tabular projections, formed by cutting away the solid of one piece into a hollow, so as to make a projection in the other in such a manner that they may correctly fit, the buts preventing the pieces from drawing asunder

Coal belongs to the third series of the Wernerian principle, viz., carboniferous rocks, coal measures, carboniferous limestone, and old red sandstone; it is admitted to be of vegetable origin, and comprises—1. Lignites, a species of mineral charcoal or intermediate gradation from wood to coal; 2. Ordinary bituminous coal, of numerous varieties; 3. Anthracite, found generally in connection with the lowest portion of the third series, and sometimes in the primary rocks themselves. Coal, then, appears to have been formed of large vegetable masses, of considerable extent, in strata varying from a few inches to many feet in depth, the strata alternating with rocks wonderfully uniform, and which consist, in most cases, of the following: sandstone, slate clay or shale, fire-clay, ironstone, limestone, &c. Rocks are found participating of both clay

and sandstone texture, greatly predominating. The coal beds are indiscriminately accompanied by rocks either of sandstone or shale, which often rest upon fire-clay. It is in the shale accompanying the coal that the fossil impressions are so numerous; for they are seldom found in the sandstones, or in the shales considerably distant from the coal beds. The organic remains of coal formation consist of many shells of fresh-water origin. The fossils, with land plants, occur in great abundance and variety, belonging to extinct species, but bearing considerable analogy to those now growing only in tropical climates. These plants are mostly succulent, and are of enormous growth

Coal-gas. Carburetted hydrogen, coal-gas, when freed from the obnoxious foreign gas, may be propelled in streams out of small apertures, which, when lighted, form jets of flame, and are called gas-lights

Coal-tar, tar made from bituminous coal

Coamings, in ships, raised work round the hatches, to prevent water from getting down into the hold

Coat. Mast-coat is a piece of canvas tarred or painted, placed round a mast or bowsprit where it enters the deck

Coat, in building, a stratum or thickness of plaster-work

Cob (Cornish), to break or bruise: a cobber, a bruiser of tin. Cobbed ore is spoiled which is broken out of the solid large stones with sledges, and not put to water, being the best ore: the same as bing ore in the lead mines

Cobalt. The ancient name for this mineral is not known. Theophrastus mentions its use for staining glass. No cobalt has been discovered in any of the remains of ancient painting. It makes a colour, according to Vitruvius, between scarlet and purple

Cobalt, in chemistry, a metal, when pure, of a white colour, inclining to bluish or steel gray: at the common temperature its specific gravity is more than 8·5

Cobalt-blue is the name now appropriated to the modern improved blue prepared with metallic cobalt, or its oxides, although it properly belongs to a class of pigments including Saxon blue, Dutch ultramarine, Thenard's blue, royal blue, Hungary blue, smalt, Zaffoe or enamel blue, and Dumont's blue. These differ principally in their degrees of purity, from the nature of the earths with which they are compounded

Cobalt-green. There are two pigments of this denomination, the one a compound of cobalt-blue and chromic yellow, which partakes of the qualities of those pigments, and may be formed on the palette

Coboose, the place where the victuals are cooked on board of merchant and passenger ships

Cob wall, a wall built of unburnt clay mixed with straw

Cochineal is extremely rich in the finest red colouring matter, and has been long employed in scarlet dyeing, and in the manufacture of carmine

Cochlea, a term used by the ancients to denote something of a spiral form; a spiral pump for raising water, &c.

Cock, or stop-cock, a kind of valve contrived for the purpose of permitting or arresting at pleasure the flow of a liquid through a pipe

Cock-boat, a small boat used on rivers

Cock-pit, that part of a ship which is appropriated to the use of the surgeon, being the place where the wounded are dressed; it is near the hatchway, and under the lower gun-deck

Cockle, the skiorl of the Swedes and the school of the Germans: a laminated mineral substance of a blackish brown colour, like tin

Cocoa wood, the heart of which is seldom sound, is much used in turnery

Coctilis, according to Pliny, a brick hardened by burning

Cod-line, an eighteen-thread line

Co-efficients, in algebra, are numbers or letters prefixed to other letters or unknown quantities, into which they are supposed to be multiplied; and therefore with such letters, or the quantities represented by them, making a product, or co-efficient product

Cœlum, according to Vitruvius, a soffit or cieling

Cœnobium, anciently a monastery of monks or friars

Côfer, in Cornish mining, a small wooden trough which receives the tin cleansed from its impurities or slime

Coffee-tree, a wood of a light greenish brown, close-grained, and small in stature, sometimes used by cabinet-makers

Coffer, a deep panel in a ceiling; also applied to a casket for keeping jewels, and sometimes to a chest

Coffer-dam, a hollow space formed by a double range of piles, with clay rammed in between, for the purpose of constructing an entrance lock to a canal, dock, or basin, or for the piers of a bridge

Coffin, in Cornish mining, old workings which were all worked open to grass, without any shafts, by digging and casting up the tin stuff from one stall of boards to another

Coffin, a wooden case in which a dead body is placed, sometimes encased in lead: anciently, stone coffins were used for interment

Cog, the wooden tooth of a large wheel

Cog-teeth are formed of a different material from the body of the wheel: a timber tooth on a cog-wheel is one made of wood, when the teeth stand perpendically to the plane of the wheel

Cog-wheel, an iron wheel with wooden teeth or cogs

Cohesion of fluids. M. Monge and *others* assert that the phenomena of capillary tubes are referable to the cohesive attraction of the superficial particles only of the fluids employed, and that the surface must consequently be formed into curves of the nature of lintearіæ, which are supposed to be the results of a uniform tension of a surface resisting the pressure of a fluid, either uniform or varying according to a given law

Cohesion, the attraction which takes place between the particles of bodies, denoting that force by which the particles firmly cohere

Cohesion and resistance of fluids, as examined by the force of torsion. Pressure does not augment the friction; on the contrary, the resistance is greater when the immersion is only partial. Greasing wood does not lessen the friction: the friction of oil is 17½ times as great as that of water. A part of the friction is proportional to the velocity: the constant part is almost insensible. Thus a circle ·195 metre in diameter, turning in water with a velocity equal to ·14 m. in 1″, meets a resistance equivalent to a weight of 1 gramme acting on a lever of ·143 m. The portion proportional to the velocity is equivalent to ·042 gr. for a surface equal to twice such a circle moving in its own direction with a velocity of ·01 m.

Cohesive strength of materials. The force of cohesion may be defined to be that force by which the fibres or particles of a body resist separation, and is proportioned to the number of fibres in the body, or in the area of its section.

Coiling, a serpentine winding of ropes, by which they occupy a small space, and are not liable to be entangled amongst one another in working the sails of a ship

Coin or *quoin*, the angle of a building; used also for the machicolation of a wall

Coke, charred pitcoal

Coke. The most valuable of the se-

condary products of a gas establishment is coke. The best kind is obtained from coal when carbonized in large masses, in ovens constructed on purpose. In a gas manufactory, the production of coke being of minor importance to the formation of good gas, it is generally of an inferior quality to that made in coke ovens, where it is the primary, and indeed sole object for which the coal is carbonized. But gas-coke is excellent for many purposes in the arts and manufactures, producing as clear a fire as that of the first quality, though it is neither so lasting nor so free from slag: for domestic use, however, it is unobjectionable, and may be burnt both in the drawing-room and kitchen with economy and comfort.

The distinguishing characters of good coke are, first, a clean, granular fracture in any direction, with a pearly lustre, inclining to that exhibited by cast iron. Secondly, density, or close proximity of its particles, which adhere together in masses, and specific gravity of 1·10, or rather higher. Thirdly, when exposed to a white heat, it consumes entirely away, without leaving either slag or ashes.

It is invariably the case that the quality of the coke is inversely as that of the gas. The manufacturer must not expect to produce *both* of the best quality. The process by which the best gas is made generally leaves the coke light, spongy, and friable, although an increase of quantity is gained; for the simple reason, that the degree of heat and other circumstances required to form perfect coke must be entirely changed when gas of a high specific gravity is to be obtained. Thus large masses of coal exposed to a red heat in close vessels are acted upon by slow degrees, the external portions preventing heat from penetrating into the interior until most of the bituminous portions are given off in condensable vapour, or as charcoal and free hydrogen; the after-products being light carburetted hydrogen, carbonic oxide, and carbonic acid gases. The residue is a carbon of a dense granular composition

Coke, as prepared for use in locomotive and other steam engines, may be regarded as *purified* coal, or coal from which the extraneous matters not conducive to combustion have been expelled by the application of heat. It appears from experiments that the heating power of every description of fuel, whether coal, coke, wood, lignite, turf, or peat, is proportional to the quantity of carbon it contains, and that from 83 to 86 per cent. of this element enters into the composition of any given weight of Newcastle, Durham, or Lancashire coal, the other ingredients being hydrogen, azote, oxygen, and ashes. The exact process which takes place in the conversion of coal into coke is not yet thoroughly understood, although the result can be readily estimated, and is found to depend, to a considerable extent, upon the manner in which the process is performed. Thus, by coking in close ovens, Welsh coal loses about 30 per cent. of its weight; but if the coking be effected in uncovered heaps of coarse lumps, as it often is in the Welsh coal and iron districts (where abundance is allowed, as the excuse for extravagance and waste), the loss of weight is from 50 to 55 per cent. While the *weight* is thus *diminished* by coking in close ovens, the *bulk* is *increased* from 22 to 23 per cent. The rapid and complete combustion of the carbon which takes place in the burning of coke has the effect of preventing, to a considerable extent, the emission of that palpable smoke which arises from the combustion of coal, and for this property coke was resorted to for use in locomotive engines, when the non-emission of smoke was imposed as one of the conditions upon which

railway companies were empowered by Act of Parliament. The practical advantages since found to be derived from the burning of coke instead of coal are, its greater power in evaporating water and producing steam, and the less rapid destruction of the boiler which ensues from its employment

Colarin, the little frieze of the capital of the Tuscan and Doric column, placed between the astragal and the annulets

Cold chisel, a piece of steel flattened and sharpened at one end, which is properly tempered, so that it may be used for cutting metal

Cold-harbour, an inn; a shelter from the cold; a protection on the wayside for travellers benighted or benumbed

Cold short iron, iron in an impure state

Cold-water well and reservoir. To effect the condensation of steam, the water is very commonly raised, by means of the cold-water pump, from a reservoir or well. This absorbs from the engine some portion of its power. Indeed, when the wells are deep, the quantity of power thus expended is so great, that the condensing system can no longer be judiciously applied. This may be known by the following investigation:

Rule.—Multiply the weight of water, in pounds, by the feet through which it passes in a minute, and divide the product by 33,000; the quotient will exhibit, friction excluded, the horses' power expended.

Example.—To condense 103°;
Weight of cold water 10 lbs. per gallon, at 62° of temperature,
Engine, nominal power . . 4 horses.
Water, per horse power . . 4 gals.
Lift of do., or height raised, 230 feet per minute.

$$\text{Hence } \frac{4 \times 40 \times 230}{33{,}000} = 1\tfrac{1}{9} \text{ h. power.}$$

Cold-water pump, the pump for supplying the water for condensation

Collar, in ships, an eye in the end or bight of a shroud or stay, to go over the mast-head

Collar, in turnery, a ring inserted in the puppet for holding the end of the mandril next the chuck, in order to make the spindle run freely and exactly

Collar, a plate of metal screwed down upon the stuffing-box of a steam engine, with a hole to allow the piston-rod to pass through

Collar of a shaft, the timber and boarding used to secure the uppermost part of a shaft in loose rubble from falling in

Collar-beam, a beam framed across and between two principal rafters

Collegiate Churches of Great Britain (list of). The Colleges generally omitted in the Books amount to 130 in number, scattered mostly over England alone, and are consequently not here included.

NAME.	ORDER.	DATE.	COUNTY.
Abergwilly	Secular Canons	1287	Carmarthenshire
Arundel	Do.	1375	Sussex
Astley	Do.	Edw. III.	Warwickshire
Attilbury		Hen. IV.	Norfolk
Axminster		temp. Athels.	Devonshire
Barnard Castle . .	Do.	Rich. III.	Durham
Battlefield	Do.	1403	Shropshire
Beverley	Do.	928	Yorkshire
Biggar		1545	Lanarkshire
Bishop Auckland . .	Do.	1239	Durham
Bunbury	Do.	1389	Cheshire
Bolton, within the *Castle of*) . .	Do.	Richard II.	Yorkshire

NAME.	ORDER.	DATE.	COUNTY.
Boseham		Henry I.	Sussex
Botham		1418	Haddingtonshire
Bothwell		1398	Lanarkshire
Bradgrove	Secular Canons	Richard II.	Kent
Brecknock		Henry VIII.	Brecknockshire
Bridgnorth		Wm. Rufus	Shropshire
Bromyard		temp. H. III.	Herefordshire
Burford		Edward	Shropshire
Carnworth		1423	Lanarkshire
Chester-le-Street . .	Do.	1286	Durham
Chumleigh		temp. Ed. I.	Devonshire
Clovelley	Do.	Richard II.	Do.
Constantin			Cornwall
Corstorphin		1429	Edinburghshire
Cotherstoke. . . .	Do.	1336	Northamptonshire
Crail		1517	Fifeshire
Crediton		905	Devonshire
Crichton		1449	Edinburghshire
Dalkeith		James V.	Do.
Darlington			Durham
Dirleton		Do.	Edinburghshire
Dirleton		1444	Haddingtonshire
Dumbarton		1450	Dumbartonshire
Dunbar		1392	Haddingtonshire
Dunglass		1450	Do.
Eton		Henry VI.	Buckinghamshire
Fotheringay . . .	Do.	1411	Northamptonshire
Foulis		Jas. II. Scot.	Forfar
Glasency	Augustine	1270	Cornwall
Gnoushall		Henry I.	Staffordshire
Graystoke		1359	Cumberland
Guthry		Jas. III. Scot.	Forfar
Hamilton		1451	Lanarkshire
Hastings		Henry I.	Sussex
Hemmingburgh . .	Secular Canons	1426	Yorkshire
Heytesbury		1300	Wiltshire
Higham Ferrers . .	Do.	Henry V.	Northamptonshire
Holyhead			Anglesea
Howden		1266	Yorkshire
Inetolingburgh . .	Do.	Edward III.	Northamptonshire
Ingham		1360	Norfolk
Irtlingburgh . . .		Richard II.	Northamptonshire
Kilmaurs		1403	Ayrshire
Kilmund.		1442	Argyleshire
Kirkheugh			Fifeshire
Lanchester	Do.	1283	Durham
Ledbury	Do.	1400	Herefordshire
Llancadane	Premonstrant	1283	Carmarthenshire
Llandewi Brevi . .		1187	Cardiganshire
Ludlow			Shropshire
Maidstone	Secular Canons	1269	Kent
Manton		Edward III.	Rutlandshire
Maybole		1441	Ayrshire

NAME.	ORDER.	DATE.	COUNTY, &c.
Merewell	Secular Canons		Hampshire
Methvin		1433	Perthshire
Mettingham . . .		Richard II.	Suffolk
Middleham	Do.	1476	Yorkshire
Newark	Do.	1330	Leicestershire
Newport	Do.		Shropshire
North Cadbury . .	Do.	Henry V.	Somersetshire
Northwell	Do.	temp. H. IV.	Bedfordshire
Norton			Durham
Norton sub Cross . .		Edward III.	Norfolk
Noseley		temp. Ed. I.	Leicestershire
Ottery		Wm. Conq.	Devonshire
Penkridge		John	Staffordshire
Pleshy	Do.	Richard II.	Essex
Ponsbury			Shropshire
Restrairig		1515	Edinburghshire
Roslin		1446	Do.
Rotherham	Do.	1481	Yorkshire
Rushworth	Do.	1342	Norfolk
Ruthyn		1310	Denbighshire
Semple		1505	Renfrewshire
Seton		1493	Edinburghshire
Shottesbrooke . . .	Do.	1337	Berkshire
Sibthorp	Do.	Edward II.	Nottinghamshire
South Malling . . .			Sussex
Southwell	Do.	630	Nottinghamshire
Stafford			Staffordshire
Staindrop	Do.	temp. Hen. IV	Durham
Stansted le Thele . .	Do.	1315	Hertfordshire
Stoke	Do.	1115	Suffolk
Stratford on Avon .		Edward III.	Warwickshire
St. Buriens			Cornwall
St. David's	Do.	1365	Pembrokeshire
St. Elizabeth . . .	Do.	1300	Winchester
St. Giles		1466	Edinburgh
St. Martin's le Grand	Do.	700	London
St. Mary	Do.	1123	Warwick
St. Mary	Do.	King Steph.	Stafford
St. Mary's			Edinburgh
St. Mary Magdalen .		1426	Linlithgowshire
St. Mary Ottery . .	Do.	1000	Devonshire
St. Michael, Crooked lane	Do.	1380	London
St. Salvator		1458	Fifeshire
St. Stephen's . . .	Benedictine	1292	Westminster
Sudbury	Secular Canons	1374	Suffolk
Tamworth			Staffordshire
Tattershall	Do.	Henry VI.	Lincolnshire
Tayne		1481	Ross-shire
Thornton upon Humber	Augustine	1139	Lincolnshire
Tomson		Edward III.	Norfolk
Tonge	Secular Canons	1410	Shropshire
Totenhall		Wm. Conq.	Staffordshire

NAME.	ORDER.	DATE.	COUNTY.
Towcester		Henry VI.	Northamptonshire
Trinity		1463	Edinburghshire
Tullibardine . . .		1446	Perthshire
Tuxford	Secular Canons	Edward III.	Nottinghamshire
Wallingford. . . .	Do.	Edward I.	Berkshire
Warwick		1123	Warwickshire
Westbury	Do.	824	Gloucestershire
Winburn			Dorsetshire
Windsor, (St. George's Chapel)	Do.	1349	Berkshire
Wingfield		Wm. Rufus	Suffolk
Wingham	Do.	1286	Kent
Wenslow	Do.	Richard II.	Yorkshire
Wolverhampton . .	Do.	996	Staffordshire
Wye	Do.	1447	Kent
Wykeham	Do.	1387	Winchester
Yester			Haddingtonshire

Collision, in mechanics. Whenever two bodies act on each other so as to change the direction of their relative motions, by means of any forces which preserve their activity undiminished at equal distances on every side, the relative velocities with which the bodies approach to or recede from each other will always be equal at equal distances

Colluviarium, anciently a well or opening formed at intervals in the channel of an aqueduct for procuring a free current of air along its course, and to facilitate the operation of clearing away foul deposits left by the waters

Cologne earth is a native pigment, similar to the Vandyke brown in its uses and properties as a colour

Colonnade, a range of columns, whether attached or insulated, and supporting an entablature

Colosseum, a name given to the theatre of Vespasian, either from its magnitude or from its colossal statue of Nero; also the name of a fine building in the Regent's Park

Colossus, a statue of gigantic dimensions, or very much beyond the proportions of nature

Colour. The term colour being used synonymously for pigment is the cause of much ambiguity, particularly when speaking of colours as sensible or in the abstract; it would be well, therefore, if the term pigment were alone used to denote the material colours of the palette

Colouring, in painting, the art of disposing the tints, so as to produce either an imitation of the natural colours of the objects represented, or force and brightness of effect

Colouring, though a subject greatly inferior to many others which the painter must study, is yet of sufficient importance to employ a considerable share of his attention; and to excel in it, he must be well acquainted with that part of optics which has the nature of light and colours for its object. Light, however simple and uncompounded it may appear, is nevertheless made up, as it were, of several distinct substances; and the number and quantity of component parts have been happily discovered by the moderns

Colours (symbolic), in antiquity, the middle ages, and modern times.

The history of symbolic colours is but little known. Colours had the same signification amongst all nations of the remotest antiquity: this conformity indicates a common origin, which extends to the earliest

state of humanity, and develops its highest energies in the religion of Persia: the dualism of light and darkness presents, in effect, the two types of colours which become the symbols of two principles, benevolence and malevolence. The ancients admitted but two primitive colours, white and black, whence all others are derived.

The language of colours, intimately connected with religion, passed into India, China, Egypt, Greece, and Rome, and re-appeared in the middle ages; the large windows of Gothic cathedrals found their explanation in the books of the Zends, the Vedas, and the paintings of the Egyptian temples.

Among the Egyptians, the prophets did not allow metal-founders or statuaries to represent the gods, lest they should deviate from the rules.

At Rome, the penalty of death was incurred by selling or being clothed in a purple stuff. At this day, in China, any one who wears or buys clothes with the prohibited design of the dragon or phœnix, is subjected to 300 stripes and three years' banishment.

Symbolism explains this severity of laws and customs: to each colour, to each pattern, appertained a religious or political idea; to change or to alter it was a crime of apostacy or of rebellion.

Archæologists have remarked that Indian and Egyptian paintings, and those of Greek origin, named Etruscan, are composed of plain tints of a brilliant colour, but without demi-tints; the pattern and the colour had a necessary signification, —it was essentially restrictive: perspective, chiaro-oscuro, and demi-tints, would have led to confusion.

Christianity, in recalling these forgotten significations, restores a new energy to the language of colours: the doctrine taught by Christ was not therefore new, since *it borrowed the* symbols of ancient religions. The Son of God, in leading back mankind to the truth, came not to change, but to fulfil the law;—this law was the worship of the true God.

The three languages of colours, divine, consecrated, and profane, classify, in Europe, the three estates of society,—the clergy, the nobles, and the people.

The large glass windows of Christian churches, like the paintings of Egypt, have a double signification,—the apparent and the hidden; the one is for the uninitiated, and the other applies itself to the mystic creeds. The theocratic era lasts to the renaissance; at this epoch, symbolic expressions are extinct; the divine language of colours is forgotten,—painting became an art, and is no longer a science.

The aristocratic era commences; and symbolism, banished from the church, takes refuge at the court: disdained by painting, it is found again in heraldry. Modern painting still preserves its symbolism in church pictures: St. John wears a green robe, Christ and the Virgin are likewise draped in red and blue, and God in white.

Natural philosophy recognizes seven colours, which form the solar ray, decomposed by the prism; namely, violet, indigo, blue, green, yellow, orange, and red. Painting admits but five primitives,—the first and last of which are rejected by natural philosophy,—white, yellow, red, blue, and black. From the combination of these five colours every hue is produced.

According to symbolism, two principles produce all colours, light and darkness.

Light is represented by white, and darkness by black; but light does not exist but by fire, the symbol of which is red: setting out from this basis, symbolism admits two primitive colours, red and white. Black was considered as the negation of colours, and attributed to

the spirit of darkness; red is the symbol of divine love; white, the symbol of divine wisdom. From these two attributes of God, love and wisdom, the creation of the universe emanates.

Secondary colours represent different combinations of the two principles; yellow emanates from red and white; it is the symbol of revelation of the love and of the wisdom of God.

Blue emanates likewise from red and white; it indicates divine wisdom manifested by life, by the spirit or the breath of God (air, azure); it is the symbol of the spirit of truth.

Green is formed by the union of yellow and blue; it indicates the manifestation of love and wisdom in action; it was the symbol of charity, and of the regeneration of the soul by works.

Gold and yellow were, in Christian symbolism, the emblems of faith: St. Peter was represented by the illuminators and miniaturists of the middle ages with a golden-yellow robe, and the rod or the key in his hand.

Christianity restored truth to mankind, and re-instated symbolic language in its original purity. In the transfiguration, the countenance of our Lord became resplendent as the sun, and his vesture shone like the light. Such, in their highest energy, are the symbols of divine love and wisdom. The angel who rolled away the stone from the sepulchre reproduced them in an inferior order, — his face shone like lightning, and his robe was white as snow. Finally, in the last degree, appeared the just, in robes washed white in the blood of the Lamb. The artists of the middle ages preserved their precious traditions, and gave to Jesus Christ, after the resurrection, white or red costume.

Columbaria, the holes left in walls for the insertion of pieces of timber; so called from resembling the niches of a pigeon-house. The niches of a mausoleum, made to receive the cineral urns, were likewise termed columbaria

Columbarium, a place of sepulture used for the ashes of the Romans, after the custom of burning the dead had been introduced among them

Columen, the term applied to the upright timbers of a roof, corresponding to the modern king-posts

Column, in architecture, a member of a cylindrical form, consisting of a base, a shaft or body, and a capital. It differs from the pilaster, which is square on the plan. Columns should always stand perpendicularly

Columna (Latin), a pillar or column, used in architecture (as described in the orders), placed upright for support of buildings, principally wrought in stone, and made decorative in conformity to the order and style of architectural composition

Columns, in architecture, according to Vitruvius, of the three orders. The proportions of Corinthian columns are in every respect, excepting their capitals, similar to those of Ionic; although their form is more graceful and proportionably more delicate, by reason of the greater height of the capitals; for Ionic capitals are a third part only of the lower diameter of the columns, whereas the Corinthian capital is equal in height to an entire diameter. The peculiar character of the capitals, which admits of their being higher than those of Ionic columns by two-thirds of a diameter, gives beauty to them, by permitting an increase of the height without violating the laws of symmetry

Combustion, the operation of fire upon an inflammable substance, by which it smokes, flames, and is reduced to ashes

Combustion, Spontaneous. Few or no chemical combinations can take place without a disturbance in the equilibrium of caloric in the substances to be so combined; and when caloric is thereby evolved in sufficient extent and rapidity, and when one or all the bodies engaged may be freely combustible, ignition takes place. When this is unintentional, or is the result of ignorance or carelessness, it is convenient to call it *spontaneous combustion.*

Thus we frequently hear of hayricks, &c., on fire; occasionally, of carts loaded with quicklime being burned by the rain falling upon the lime. There are also somewhat apochryphal accounts of coal in coal-yards being destroyed in like manner. But the most important instance of this class, as far as regards the preservation of Government establishments, is the combustion that infallibly and rapidly ensues when greasy hemp, flax, or cotton, is allowed to remain loosely heaped together, in any quantity, in a confined unventilated space.

Full proof of this has been made by experiment in the dockyards; and there is much reason to attribute many fires in former days to carelessness in the rope-walks and hemp stores; in consequence of which, rigorous orders have been of late years issued as to the immediate disposal of loose oakum and hemp sweepings—all more or less greased or oiled. The very oil-rags used by engravers in cleaning plates, when heaped together to any amount, will be consumed in a few hours.

The combination in question seems to be between the oil and the oxygen of the atmosphere. Oil has always an affinity for oxygen; though, when the bulk of the former is considerable in proportion to the surface, the action is but feeble, and the results not ordinarily appreciable: but in the case of admixture of such fibrous vegetable bodies as hemp, flax, or cotton with oily matters, where the ratio of surface to solidity is great, and when the conditions for accumulating heat are favourable,—this accumulation soon produces ignition amongst such inflammable bodies as those just enumerated

Come. 'Come home;' said of an anchor when it is broken from the ground, and drags. To 'come up' a rope or tackle, is to slack it off

Commandry, a religious house belonging to a body of knights of the order of St. Bernard and St. Anthony

Commissure, the joint between two stones in masonry

Common pitch, an old term still applied by country workmen to a roof in which the length of the rafters is about three-fourths of the entire span

Common sewer of Rome: it was near the Senatorian bridge, and was 16 feet in diameter

Communication valves, the valves in a steam-pipe which connects two boilers to an engine, for cutting off the communication between either boiler and the engine

Communion table, a piece of church furniture usually placed near the wall of the east end of the chancel, and enclosed by rails, within which the clergyman stands to administer the Sacrament

Companion, a wooden covering over the staircase to a ship's cabin

Compartition, the division or distribution of the ground-plan of an edifice into its various apartments

Compartment of the streets within a city. According to Palladio, regard must be always had to the temperature of the air, and also to the region of heaven, or the climate under which the place is situated; because where the air is cold or temperate, there the streets ought to be made large and noble, since thereby the city will become

more wholesome, convenient, and beautiful: it being certain that by how much less piercing, and withal by how much freer the air is, by so much the less will it offend the head; and therefore by how much more a town is situated in a cold place, or in a piercing air, and that the houses are high, by so much the longer ought the streets to be made, that they may be visited by the sun in every part of them

Compartment, a division or separate part of a general design.

Compass (Harris's magneto-electric). The inventor's object, in the application of his discovery of the steadying action of the copper ring, "is the combination of great sensitiveness with stability and simplicity of construction; so that while the needle is free to obey the magnetic force of the earth in the most perfect way, it yet remains tranquil amidst the disturbing motions to which a ship is exposed; and this stability is obtained without the aid of friction or other mechanical impediment, which often produce an apparent steadiness, or rather sluggishness of the compass (arising from indifference to motion), at the expense of accuracy.

"When the horizontal position of the card is disturbed by any alteration of dip incidental to a change of latitude, it is to be corrected by moving the silver sliders on the needle.

"Should the compass be out of use, care must be taken to let the needle hang freely in the meridian; and if put into a store-room, or otherwise set by, the card and needle should be removed altogether, and placed with the needle downward in the shallow box provided for it,—the north point being on that part of the keeper marked with a cross, thus ×. A good compass is liable to deterioration and damage when stowed away without regard to its magnetic properties, and without due care being taken to preserve the agate and the point of suspension in a perfect state."

Compasses, an instrument with two long legs, working on a centre pin at one extremity; used for drawing circles, measuring distances, setting out work, &c.

Compass-headed, in ancient architecture, circular

Compass-plane, in joinery, a tool similar to the smoothing-plane in size and shape, but the sole is convex, and the convexity is in the direction of the length of the plane. The use of the compass-plane is to form a concave cylindrical surface, when the wood to be wrought upon is bent with the fibres in the direction of the curve, which is in a plane surface perpendicular to the axis of the cylinder: consequently, compass-planes must be of various sizes, in order to accommodate different diameters.

Compass-roof, a roof in which the braces of the timbers are inclined so as to form a sort of arch.

Compass-saw, in joinery, a tool for cutting the surfaces of wood into curved surfaces: for this purpose it is narrow, without a back, thicker on the cutting edge, as the teeth have no set: the plate is about an inch broad, next to the handle, and diminishes to about one quarter of an inch at the other extremity; there are about five teeth in the inch: the handle is single

Compass-window, a bay window, or oriel

Complement (the) of an arch or angle is what it wants of 90 degrees: thus the complement of 50° is 40°, and the complement of 40° is 50°.

Compluvium (Latin), the interval between the roofs of porticoes which surround the cavædium. The rain was admitted through this opening, and fell upon the area below, which was termed by some authors the *impluvium*

Composite Order: by some considered

not a distinct order, but a variety of the Corinthian. For its height and proportion, see *Architecture, Orders.*

Care must be taken in Composite as well as in Corinthian capitals, that the feet of the lower leaves do not project beyond the upper part of the column, as at St. Carlo, in the Corso at Rome, and at the Banqueting-house in London; for nothing can be uglier. Neither are these leaves, as they mount, to bend forwards, as in many of the antiques, and in some modern buildings, because they then hide a considerable part of the upper row of leaves, and give a stunted disagreeable form to the whole capital. The different divisions of the acanthus leaf, and bunches of olive or parsley which compose the total of each leaf, must be firmly marked, and massed in a very distinct manner: the stems that spring from between the upper leaves are to be kept low upon the vase of the capital, while rising between the leaves, then spring gradually forwards, to form the different volutes; and the ornaments, which sometimes are used to adorn the sides of the angular volutes, are never to project beyond the fillets between which they are confined.

Composition of motion, in mechanics, an assemblage of several directions of motion resulting from several powers acting in different though not in opposite directions

Composition, in painting, is a tasteful and proper distribution of the objects of a picture, in grouping, in the attitudes, and in the draperies, and the management of the background

Composition and symmetry of temples. The several parts which constitute a temple ought to be subject to the laws of symmetry, the principles of which should be familiar to all who profess the science *of architecture.* Symmetry results from proportion, which, in the Greek language, is termed analogy. Proportion is the commensuration of the various constituent parts with the whole; in the existence of which, symmetry is found to consist; for no building can possess the attributes of composition in which symmetry and proportion are disregarded, nor unless there exists that perfect conformation of parts which may be observed in a well-formed human being

Compound arch, according to Professor Willis, an arch which has the archivolt moulded or formed into a series of square recesses and angles, on the principle that "it may be resolved into a number of concentric archways successively placed within and behind each other"

Compound pier, a term applied to a clustered column

Compression, the result of pressing or squeezing matter so as to set its parts nearer to each other, and to make it occupy less space

Computation, the method of estimating time, weights, measures, &c.

Concamerate, to arch over

Concameratio, arched work

Concave, a term denoting the curvilinear vacuity of hollow bodies

Concentric, having a common centre; as concentric circles, ellipses, &c.

Concha, according to Dr. Whewell, a term for the concave ribless surface of a vault

Conclave, a private or secret council; an inner room for meeting privately

Concluding line, a small line leading through the centre of the steps of a rope or Jacob's ladder

Concrete, a composition of lime, sand, pebbles, or other materials, now commonly used for the foundations of buildings.

The general employment of the mixture of lime and gravel, commonly known by the name of concrete, in all foundations where, from the nature of the soil, pre-

cautions against partial settlements appear necessary, and the great probability of an extension of its use in situations where the materials of which it is composed are easily and cheaply procured, must of course render it a subject of great interest to the engineer.

Much valuable information on this subject will be found in a prize essay by Mr. G. Godwin, published in the 'Transactions of the Institute of British Architects.' In this essay, many instances are brought forward of the employment by the ancients of a mixture analogous to concrete, both for foundations and for walls. Several cases are also mentioned in which, of late years, it has been used advantageously for foundations, by some of the most distinguished architects and civil engineers. In these latter instances, the proportion of the ingredients varies from one of lime and two of gravel, to one of lime and twelve of gravel,—the lime being in most cases Dorking lime, and the gravel, Thames ballast. The proportion, however, most commonly used now, in and about London, is one of lime to seven of ballast; though, from experiments made at the building of the Westminster New Bridewell, it would appear that one of lime to eight of ballast made the most perfect concretion.

Concrete, compounded solely of lime and screened stones, will never assume a consistence at all equal to that of which sand forms a part. The north wing of Buckingham Palace affords an instance of this: it was first erected on a mass of concrete composed of lime and stones, and when subsequent alterations made it necessary to take down the building and remove the foundation, this was found not to have concreted into a mass.

Mr. Godwin states, as the result of several experiments, that two parts of stones and *one of sand*, with sufficient lime (dependent on the quality of the material) to make good mortar with the latter, formed the best concrete. As the quality of the concrete depends, therefore, on the goodness of the mortar composed of the lime and sand, and as this must vary with the quality of the lime, no fixed proportions can of course be laid down which will suit every case. The proportions must be determined by experiment; but in no case should the quantity of sand be less than double that of the lime.

The best mode of compounding the concrete is to thoroughly mix the lime, previously ground, with the ballast in a dry state; sufficient water being then thrown over it to effect a perfect mixture, it should be turned over at least twice with shovels, and then wheeled away instantly for use. In some cases, where a great quantity of concrete has to be used, it has been found advisable to employ a pug-mill to mix the ingredients: in every case it should be used hot.

With regard to the quantity of water that should be employed in forming concrete, there is some difference of opinion; but as it is usually desirable that the mass should set as rapidly as possible, it is not advisable to use more water than is necessary to bring about a perfect mixture of the ingredients. A great change of bulk takes place in the ingredients of concrete when mixed together: a cubic yard of ballast, with the due proportion of lime and water, will not make a cubic yard of concrete. Mr. Godwin, from several experiments made with Thames ballast, concludes that the diminution is about one-fifth. To form a cubic yard, therefore, of concrete, the proportion of lime being $\frac{1}{8}$th of the quantity of ballast, it requires about 30 cubic feet of ballast, and $3\frac{3}{4}$ cubic feet of ground lime, with sufficient water to effect the admixture.

An expansion takes place in the concrete during the slaking of the lime, of which an important use has been made in the underpinning of walls: the amount of this expansion has been found to be about ⅜ths of an inch to every foot in height; and the size thus gained, the concrete never loses.

The examples from which the above rules are deduced are principally of buildings erected in or about London; the lime used is chiefly from Dorking, and the ballast from the Thames. It is very desirable that a more extended collection of facts should be made, that the proportions of the materials, when other limes and gravels are used, should be stated, in order that some certain rules may be laid down by which the employment of concrete may be regulated under the various circumstances which continually present themselves in practice.

The Dorking and Halling limes are slightly hydraulic. Will common limes, such as chalk, and common stone-lime, answer for forming foundations of concrete, where the soil, although damp, is not exposed to running water? Is it possible, even with hydraulic lime, to form a mass of concrete in running water? If common lime will not answer, may it not be made efficient by a slight mixture of cement? These, and questions similar to these, are of great interest; and facts which elucidate them will be valuable contributions to the stock of knowledge on this subject.

It is a question for consideration, whether a great variety of sizes in the materials used would not form the most solid as well as the hardest wall. The walls of the fortress of Ciudad Rodrigo, in Spain, are of concrete. The marks of the boards which retained the semi-fluid matter in their construction are every where perfectly visible; and besides sand and gravel, there are every where large quantities of round boulder-stones in the walls, from 4 to 6 inches in diameter, procured from the ground around the city, which is every where covered with them.

Condensation, the conversion of vapour into water by cold

Condenser, in steam engines, the vessel connected with the exhaust-port of the cylinder of a low-pressure engine, and also with the air-pump, by a passage at the bottom fitted by the foot-valve of the pump: it receives the steam from the cylinder, and condenses it by a jet of cold water, thus forming a vacuum for the return stroke: the water, air, &c. is then drawn off by the air-pump, and discharged into the hot well

Conditorium, a secret place; a sepulchre; a vault

Conduction, electrical, a series of phenomena in electricity, giving origin to a classification of substances as conductors of electricity. The substances which properly come under this *conducting* or *non-electric* class are principally as follows:

LIST OF ELECTRICAL CONDUCTORS.

Every metallic substance known.
Well-burned charcoal.
Plumbago.
Concentrated and diluted acids, and saline fluids.
Water, and moist vegetable matter.
Living animal matter.
Flame—smoke—steam.

The distinctive difference in the conducting and non-conducting property of bodies may be readily illustrated in the following way:

Excite a glass tube and wire, and bring the ball of the wire into contact with any of the *electrics*, as a rod of glass, a stick of sealing-wax, or brimstone rendered perfectly dry: the attractive power of the ball and wire, together with the tube, will not be in any sensible degree impaired. Let the elec-

trified ball now touch the walls of the room or other conducting substance communicating with the ground; the attractive power will instantly vanish.

It is evident from these facts that all electric substances are *non-conductors* or *insulators*, as they are appropriately termed; whilst, on the other hand, *non-electric substances* are transmitters or conductors of electrical action.

When, therefore, any conducting substance is placed on an electrical support, such as a rod of glass or shell-lac, it is considered to be insulated, and is termed an *insulated conductor;* when electrified by contact with any excited or other electrified body, it is said to be *charged.* The electrical charge thus communicated to an insulated conductor appears to be collected about its surface, and to be rather dependent on that than on the solid content. Thus, if two metallic spheres or cylinders, the one solid, the other hollow and extremely light, be suspended by silk lines, or placed on dry insulating supports, and be charged by contacts with an excited tube, the attractive energy of each upon any light substance presented to it will be found quite alike in each. In this experiment the insulators must be very dry and perfect.

The best insulating substances are of the vitreous and resinous class, such as shell-lac, brimstone, dry glass rods, vitrified and crystalline bodies: to these may be added silk.

The best conducting substances are principally metallic bodies, saline fluids, and common charcoal.

It should, however, be here understood, that modern researches, especially those of Faraday, lead us to conclude that there are really no substances which perfectly conduct or perfectly obstruct electrical action. The insulating and conducting power is, in fact, a difference of degree only: still, the extreme differences are so great, that if classed in relation to such differences, those at the extremes of the series admit of being considered the one as insulators, the other as conductors; whilst the intermediate terms are made up of substances which may be considered as imperfect, taken as either. Conversely, every substance is capable of excitation by friction; yet the differences in this respect are so great as to admit of some bodies being called electrics and others non-electrics, with an intermediate class between these extremes, which may be termed imperfect electrics.

Series of conductors and insulators.—Metals and concentrated acids are found at the conducting extremity of such a series,—shell-lac, brimstone, all vitreous and resinous bodies, at the other or electric extremity; whilst the imperfect or intermediate substances comprise such matter as common earth and stones, dry chalk, marble, porcelain, paper, and alkaline matter.

The attractive power evinced by any electrical body in a state of excitation, although the first and usually the most evident electrical effect, is yet not the only force which seems to result from this curious condition of common matter. On a closer examination of the phenomena, a new class of facts present themselves, of remarkable interest. If the excitation be considerable, and the attracted body insulated, it will, after being drawn into contact with the electrified substance, rebound from it with great violence, as if repelled by some new power, and will not be again attracted until it has had conducting communication with the earth, or some other mass of matter capable of reducing it to its original condition before the contact.

Conduit, a structure forming a reservoir for water, and from which it is drawn for use

Cone, a solid body having a circular base, and its other extremity terminating in a single point or vertex. Cones are either right or oblique

Cone-plate, a strong plate of cast iron fixed vertically to the bed of a lathe, with a conical hole in it, to form a support for the end of a shaft which it is required to bore

Confessional, a recess or seat in which the priest sits to hear the confessions of penitents

Conge, another name for the echinus or quarter-round, as also for the cavetto: the former is called the swelling conge, the latter the hollow conge

Conic sections, the curves formed by the intersection of a circular cone and a plane; the former being either oblique or right

Conical points, in turnery, the cones fixed in the pillars for supporting the body to be turned: that on the right hand is called the fore centre, and that on the left hand, the back centre

Conissinet, the stone which crowns a pier, or that lies immediately over the capital of the impost, and under the sweep. The bed of it is level below, and curved above, receiving the first rise or spring of the arch or vault

Conisterium, an apartment in the palæstra, in which sand was kept for sprinkling the athletæ, after they had been anointed

Connecting-rods, in locomotive engines, the strong iron rods which connect the piston to the driving-wheel axle, and thus give motion to all the machinery

Connecting-rods, in locomotive engines, *outside* or *side rods*, those which connect together the wheels of goods engines. They are seen outside the wheels, making an irregular forward motion, like water-*men rowing* a boat. By connect-*ing the wheels* together, one pair cannot slip without th and the greatest practica sion is thus obtained

Connecting-rod straps, in lo engines, strong pieces of like the letter ⊂, whicl ends of the connecting- into which the axle-bearin in two parts. They are to their respective ends o by keys and cotters, w taken out, and the hal bearing also, when a co rod has to be put on. and half-bearing are ther over the axle or cross-l other half-bearing put strap, the end of the roc up against the bearing, an by the keys and cotters. off a rod is of course the putting one on

Connecting-rod bearings, in tive engines, the gun-composition-metal bearir into the straps, to suit t cular part they are to wor

Conning, directing the helr steering a vessel

Conservation, the ceremony fying or making holy

Conservatory, a superior greenhouse, for preservin and rare exotic plants. with beds of the finest into which the trees and removed for culture and tion. Its construction is pacious than the ordina house, and it is furnished rior style, provided with mission of light, and, in with flues or boiling-wa to raise the temperature cessary, and also contri the introduction of fresh

Consideration (the), which to have before he begins Palladio says, "The first requires our considerati we are about to build, is and the upright of the propose to erect." Thr according to Vitruvius, a

to be considered, without which a building cannot be of any value. These are, conveniency, solidity, and beauty: for no edifice can be allowed to be perfect, if it be commodious and not durable; or, if being durable, it be subject to many inconveniences; or if having both solidity and conveniency, it has no beauty or uniformity.

Consistory court, a spiritual court, formerly held in the nave of the cathedral church

Console, a bracket or truss, mostly with scrolls or volutes at the two ends, of unequal size and contrasted, but connected by a flowing line from the back of the upper one to the inner convolving face of the lower

Constant white, permanent white, or barytic white, is a sulphate of barytes, and, when well prepared and free from acid, is one of the best whites for water-painting, being of superior body in water, but destitute of this quality in oil

Construction, in architecture: for this the chief requisites are, magnitude and strength, and the art of distributing the different forces and strains of the parts and materials of a building in so scientific a manner as to avoid failure and to insure durability

Continuous imposts, according to Professor Willis, are the mouldings of an arch which are continued without interruption down the uprights to the ground or base, the impost point having no mark or distinction of any kind

Contouring (surveying altitudes and levels). This term is applied to the outline of any figure, and consequently to that of any section of a solid body; but when used professionally, in connection with the forms of ground, or of works of defence, the outline of a horizontal section of the ground, or works, is alone to be understood by it.

When the forms of ground, or works, are described by contours, or horizontal sections, these sections are taken at some fixed vertical interval from each other, suited to the scale of the drawing, or to the subject in hand; and the distance of each, above or below some assumed plane of comparison, is given in figures at the most convenient places on the plan. When the scale of the drawing is about 100 feet to an inch, 2 or 3 feet will be found a convenient vertical interval between the contours; and however large the scale of the plan, it will scarcely be found necessary to obtain contours with a less vertical interval than 2 feet. If the scale of the plan be about 250 feet to an inch, or the ordinary special survey scale of 4 chains to an inch, 5 feet will prove a convenient vertical interval; and with a horizontal scale of from 500 to 800 feet per inch, 10 feet may be taken as the vertical interval.

In tracing and surveying the contours of ground, the following process may be adopted: complete the survey of the occupation of the ground, the streams, &c., and determine carefully the altitudes of the trigonometrical points employed above the intended place of comparison: take an accurate trace from the plot of one of the triangles, which, if the distances between the trigonometrical points are properly proportioned to the scale of the plan, will generally be a convenient piece in point of size to contour: take this trace to the ground, and find upon the ground, and mark upon the trace, the points where each of the intended contours will cut the boundary lines of the triangle.

Contraction, the effect of cold upon a warm body, causing a diminution in its size by the particles approaching each other

Contramure, an out-wall built about the wall of a city or fortification

Convent, a building appropriated to religious persons; a nunnery

Convocation and *Convocators*, or parliament of tinners. All Stannary laws are enacted by the several convocations, and carry with them all the force and law of acts of parliament.

Coopertorium, the roof of a building

Co-ordinates, in the theory of curves, any absciss and its corresponding ordinate

Coping, the reversing course of a wall, either flat or sloping on the upper surface, to throw off water

Coppe-house, anciently a tool-house

Copper, one of the six primitive metals, and the most ductile and malleable after gold and silver. Of this metal and lapis calaminaris is made brass, which is comparatively a modern invention

Copper green (colour); the appellation of a class rather than of an individual pigment, under which are comprehended verdigris, verditer, malachite, mineral green, green bice, Scheele's green, Schweinfurt or Vienna green, Hungary green, emerald green, true Brunswick green, lake green, mountain green, African green, French green, Saxon green, Persian green, patent green, marine green, Olympian green, &c. The general characteristic of these greens is brightness of colour, well suited to the purposes of house-painting, but not adapted to the modesty of nature in fine art.

Coral wood is of a fine red colour, hard, and polishable

Corbel, or *Corbeille*, a short piece of timber or stone let into a wall half its length or more, as the burthen superimposed may require, to carry a weight above it, and projecting from the general face of the work: it is carved in various fanciful ways; the commonest form is, however, that of an ogee

Corbel, in Gothic architecture, a projecting stone or piece of timber which supports a superincumbent weight

Corbel-table, a row of corbels supporting a parapet or cornice

Corbel-table, a cornice supported by corbels

Corbie steps, steps up the sides of a gable, found in old houses in Flanders, Holland, &c.

Corbona, in mining, a dropper from a lode in irregular masses

Core, with the Cornish tinmen, is a division of time and labour

Corinthian Order. The three columns in the Campo Vaccino, supposed remains of the temple of Jupiter Stator, are generally allowed to be the most perfect models of the Corinthian order amongst the antiques at Rome. Palladio, in his fourth book, ~~where~~ he gives the whole profile at large, acknowledges that he never had seen any work better executed, or more delicately finished; that its parts are beautifully formed, well-proportioned, and skilfully combined; all which last qualities are certainly signified by his *Benissimo intesi*.

With these favourable sentiments, it is extraordinary that, in his design of the Corinthian order, he should have so very considerably deviated from this excellent original as scarcely to leave the smallest shadow of resemblance.

Vignola, in his Corinthian profile, has chiefly imitated the above-mentioned fragment, and the interior order of the Pantheon, another very perfect model. His composition is uncommonly beautiful, and, without dispute, superior to that of any other master: he artfully collected all the perfections of his originals, and formed a whole far preferable to either of them. (For height and proportion, see *Architecture*, *Orders*.)

Corner-stones, in architecture, the two stones which stand one in each joint of the chimney

Cornice, the projection, consisting of several members, which crowns or finishes an entablature, or the body or part to which it is annexed. The cornice used on a pedestal is called the cap of the pedestal

Cornish engine, a single-acting beam engine, used for raising water: the steam is worked very expansively, and used for the down-stroke only, to raise an immense weight, fastened to the pump-rod, at the end of the beam: the steam having acted for the down-stroke, and the entrance-valve being closed, a communication is formed between the top and bottom of the cylinder, by lifting a valve in the steam passage, called an equilibrium valve: the pressures on the piston are thus equalized, and the weight acts to force the water up, and raise the piston

Cornucopia, or horn of plenty: among architects, painters, &c., it is represented under the figure of a large horn, out of which issue fruit, flowers, &c.

Corollary, an inference or deduction

Coromandel wood, the produce of Ceylon and the coast of India, is shipped in logs and planks from Bombay and Madras; it is of a red hazel-brown colour, handsome for furniture wood, and turns well

Corona, the members constituting the uppermost of the three divisions of the entablature of a portico, or any other building in which columns are introduced: this division is termed *cornice*

Corona, that flat, square, and massy member of a cornice, more usually called the drip or larmier, whose situation is between the cymatium above and the bed-moulding below: its use is to carry the water drop by drop from the building

Corporax cloth, a linen cloth or napkin spread upon the altar, on which the host and chalice are placed at the mass in the Catholic service

Corpse-gate, a covered place at the entrance to a churchyard, intended to shelter the corpse and mourners from rain

Corridor, a gallery or open communication to the different apartments of a house

Corsa, the name given by Vitruvius to a platband or square fascia whose height is more than its projecture

Cortile, a small court enclosed by the divisions or appurtenances of a building

Cortis, in the middle ages, a court surrounded by edifices

Coryceum, a room similar to a tennis-court

Costean pits, in Cornish mining, are shallow pits sunk to trace or find tin

Costeaning, in mining, the discovering of lodes by sinking pits in their vicinity, and drawing transversely to their supposed direction

Cot, in nautical phraseology, a bed-frame suspended from the beams of the ship, or otherwise

Cotton, a white woolly or downy substance, found in a brown bud, produced by a shrub, the leaves of which resemble those of the sycamore-tree. The bud, which grows as large as a pigeon's egg, turns black when ripe, and divides at top into three parts: the cotton is as white as snow, and with the heat of the sun swells to the size of a pullet's egg. Scripture speaks of cotton.

Cotton manufactures and *trade*. Cotton was woven by the Hindoos and Chinese many centuries before the Christian era. The Egyptians are supposed to have imported woven cotton before the plant had begun to be cultivated in their country; and the Romans received woven cotton from India long before the cotton-plant was known in Europe. The extension of the manufacture of it has now become enormous. The export of cotton goods from England, in 1846, was £25,600,693 in value.

Cotton spinning: the spinning of cotton into the form of yarn or thread requires many preparatory processes; but the inventions and improvements in machinery that have been effected in recent years have rendered the process simple and of great national value

Cotton and *Calico printing*, the art

of staining woven fabrics of cotton with various figures and colours

Cotton cultivation and *trade.* The distinctive names by which cotton is known in commerce are mostly derived from the countries which produce it: the exceptions are, sea-island cotton, and upland cotton. The former of these was first cultivated in the low sandy islands near the coast of Charleston in America; while the latter is grown in the inner or upland country. The sea-island cotton is the finest of the several varieties. The upland is often called Bowed Cotton.

Cotton, gun, is prepared with cotton wool, and explodes at 400° Fahr. Gunpowder explodes at 600°

Couched, laid close, as in a stratum

Couissinet. (See *Conissinet.*)

Coulisse, any piece of timber which has grooves in it; also pieces of wood which hold the floodgates in a sluice

Counter, that part of a vessel between the bottom of the stern and the wing transom and buttock

Counterfort, a pier, buttress, or oblique wall, built up against a wall to strengthen and support it

Counter-gauge, in carpentry, a method of measuring joints by transferring the breadth of a mortise to the place on another timber where the tenon is to be made

Counter-lath, in tiling, a lath placed by the eye

Counterpoise, any weight which, placed in opposition to another weight, produces an equilibrium; but it is more commonly used to denote the weight used in the Roman balance, or steelyard

Countersinks, in joinery, are bits for widening the upper part of a hole in wood or iron, for the head of a screw or pin, and have a conical head. Those for wood have one cutter in the conic surface, and have the cutting edge more remote from the axis of the cone than any other part of the surface. Countersinks for brass have eleven or twelve cutters round the conic surface, so that the horizontal section represents a circular saw. These are called rose-countersinks. The conic angle at the vertex is about 90 degrees. Countersinks for iron have two cutting edges, forming an obtuse angle.

Count-house, a reckoning-house, in Derbyshire; a house or room on the mine used for keeping accounts of the products, &c.

Country residences. There are important advantages which deserve to be brought into notice, whether for comfort and convenience, for gratifying taste or fashion. Additional rooms appropriated for new purposes are often requisite. Formerly a gallery, although there were no works of art to fill it, was a necessary part of a mansion; of late years, the billiard-room and the conservatory enter into the arrangements of an architect; and a suit of well-planned nursery-rooms have been made a necessary part of the plan of a country mansion. The gallery is again about to resume its importance, and perhaps we may hereafter imitate the Romans in having covered walks contiguous to the house, in order to enjoy fresh air in the many rainy and snowy days at a country residence in an English winter. The irregular style admits of such additions, and loses nothing of the picturesque effect. The exterior decorations of terraces, parterres, stairs of communication, and different gardens filled with groups of the many flowery shrubs and plants, are admirably in harmony with this style of architecture. While we thus decorate closely around the house, it becomes less necessary to sacrifice so much to the park. The masonry of such irregular architecture requires not the expensive labour bestowed on a Grecian or Roman mansion. The whole should be in rough rubble-work, excepting the parapets, the corners, the windows, and doors.

Many very good designs of castellated dwellings have been, in the execution, deprived of their effect, by being built of smooth, hewn freestone. If circular or square towers are introduced in a composition of the irregular style, they should, in every case, be of great dimensions, as much for their being applied to useful rooms, as to produce that grandeur of appearance which bulk in towers always gives.

Country seats (the) of the Italians have been copied by most civilized nations of Europe; celebrated by poets, visited and admired by travellers: they have not, however, been described or represented as they deserve. They are so arranged as to produce the best effect, and advantage of the nature of the site has been taken with admirable skill. The regularities of the gardens accompany the decoration, and support the architecture. (See Parker's 'Villa Rustica,' recently published.)

Couple-close, a pair of spars of a roof; also used by heralds as a diminutive of the chevron

Coupled columns. When, from the extent between columns sometimes necessary for the introduction of doors, windows, niches, or other decorations, neither the eustylos nor the diastylos intercolumniation can be used, coupled columns are frequently introduced. In this case two sistylos intercolumniations are used; the column which would otherwise occupy the middle of the space being brought to the distance of only half a diameter (or sufficient room for the projection of the capitals) from the extreme column. The middle space will then be three diameters and a half. This species has been called araeosistylos. When buildings are small, the intercolumniations will not require such particular attention to the foregoing rules, for columns should never be placed nearer to each other than 3 feet, which will allow for the easy passage of a bulky person.

Coupling, in machinery, is the name given to various arrangements by which the parts of a machine may be connected or disconnected at pleasure, or by which a machine may be disengaged from, or re-engaged with, a revolving wheel or shaft, through which it receives motion from a steam engine, water-wheel, or other prime mover

Couplings, in mill-work: it is frequently necessary to convey motion much farther than would be practicable by any one shaft, and therefore often requisite to connect two or more shafts together. These connections are denominated couplings, and may be divided into two classes: 1st, Those having two bearings; 2ndly, Those having one bearing. Couplings having two bearings have been long in use, and before those having one bearing, and are generally more simple in their construction.

Coupling-box, a metal box for joining the ends of two shafts, so that they may revolve together

Course, a continuous range of stones or bricks, of uniform height, in the wall of a building

Course, in Cornish mining, is a tin or copper course; a phrase for working of the lode

Courses, sails that hang from a ship's lower yards: the fore-sail is called the fore-course, and the main-sail the main-course

Courts of Justice: there were in Rome twelve halls or courts of justice, where causes were heard and tried: they were adorned with statues, fine columns, and porticoes with double rows of columns

Cove, a cave, a recess; any kind of concave moulding; the concavity of an arch or of a ceiling

Coved ceiling, the upper surface of an apartment formed in an arched or coved shape at its junction with the side walls

Cover, in slating, the part of the slate that is hidden; the exposed part being called the margin

Cover-way, in roofing, the recess or internal angle left to receive the covering

Covie or *Covey*, a pantry

Coving, the exterior projection of the upper parts of a building beyond the limits of the ground-plan

Coving, a term applied to houses, &c., that project over the ground-plot

Coving of a fire-place, the vertical sides, inclining backwards and inwards, for the purpose of reflecting the heat

Cowl, a cover for the top of a chimney, made to turn round by the wind, and used to facilitate the escape of smoke

Coxswain, the person who steers a boat, and has charge of her

Crab, a wooden apparatus, something like a capstan, but not furnished with a drum-head; it is used for similar purposes, with holes made to insert the bars

Crab, a machine with three claws, used to launch ships, to heave them into the dock, or off the quay

Cradle, a frame placed under the bottom of a ship, in order to conduct her steadily into the water when she is to be launched, at which time it supports her weight while she slides down the descent or sloping passage, called the ways, which are for this purpose daubed with soap or tallow

Craft, a general name for all sorts of vessels employed to load or discharge merchant ships, or to carry alongside or return the guns, stores, or provisions of a man-of-war: such are lighters, hoys, barges, &c.

Cramp, a short bar of iron, with its ends bent so as to form three sides of a parallelogram: at one end a set-screw is inserted, so that two pieces of metal, being placed between, can be held firmly together by the screw

Crane, a machine used for hoisting and lifting stones, ponderous weights, and heavy goods, principally at wharfs and warehouses, now much employed for hoisting heavy building materials; also as travelling cranes on framed scaffolding, for the assistance of masons, bricklayers, and other artizans in building, saving the time and labour formerly so much prolonged in the execution of the work to be done. (For a succinct account of all kinds of cranes, see Glynn's work in the 'Rudimentary Series.')

Cranes, pieces of iron or timber at a vessel's sides, used to stow boats or spars upon

Crank, the condition of a vessel when she is inclined to lean over a good deal, and cannot bear much sail: this may be owing to her construction, or to her stowage

Crank, the arms projecting from the main shaft of an engine, joined together at the outer ends

Crank, in mechanics, a square piece projecting from a spindle, serving by its rotation to raise and fall the pistons of engines: it also denotes the iron support for a lantern, and the iron made fast to the stock of a bell

Crank, in machinery, is a bend in an axle, by which a reciprocating motion in a rod is made to produce a revolving motion of an axle and of a wheel which may be connected with it

Crank, in turning, that part of the axle of the fly which is bent into three knees, or right angles, and three projecting parts: one of the parts is parallel to the axis, and has the upper part of the crank-hook collared round it

Crank-axle, the driving axle connected to the piston-rods of a locomotive engine

Crank-hook, in turning, sometimes also called the connecting-rod, as it connects the treadle and the fly

Crank-pin, the cylindrical piece joining the ends of the crank arms, and attached to the connecting-rod, or, in vibrating engines, to the piston-rod: if the crank has only one arm, the pin projects from the end of it

Crayon, a chalk; a species of material for drawing. Black chalk, found in Italy, white chalk, found in France, and red chalk, form three of the best varieties of crayons: each has its own peculiar value as a drawing material.

Creazes, in mining, the work or tin in the middle part of the buddle or dressing

Credence, the small table at the side of the altar, or communion table, on which the bread and wine were formerly placed before they were consecrated

Creeper, an iron instrument like a grapnel, with four claws, used for dragging the bottom of a harbour or river, to find any thing lost

Crenelle, the embrasure of a battlement, or loopholes

Crepido, according to Pliny, any raised basement upon which other things are built or supported, as of a temple, altar, obelisk, &c.

Cresset, a candlestick or lamp to contain a light

Crest, a term in heraldry; the ornament of the helmet

Creste, the ornamented finishing surrounding a screen or canopy of a building

Crest-tiles, those used to cover the ridge of a roof, upon which they fit on the principle of a saddle

Cringle, a short piece of rope with each end spliced into the bolt-rope of a sail, confining an iron ring or thimble

Criplings, short spars at the sides of houses

Crista, a crest; the apex or highest part of a shrine

Crocket, an ornament of foliage or animals running up the back of a pediment, arch-pinnacle, or spire, from the corbels below to the finial above, in which latter the crockets on both sides appear to merge

Crockets, projecting leaves, flowers, or bunches of foliage, used in Gothic architecture to decorate the angles of spires, canopies, pinnacles, &c.

Cromlech, in British antiquity, high, broad, and flat stones, raised upon other stones set on end, apparently for the purpose of an altar

Crop, ore or tin of the first quality, after it is dressed or cleaned for smelting

Crosette, a truss, or console, in the flank or return of an architrave of a door, window, or other aperture in a wall

Crosettes, in decoration, the trusses or consoles on the flanks of the architrave, under the cornice

Cross, a gibbet constructed of two pieces of wood placed transversely, whether they cross each other at right angles at the top, like a T, or in the middle of their length, like an X

Cross, the symbol of the Christian religion

Cross, *cross crusse*, *cross bar*, *cross goffan*, *cross lode*, either a vein of a metallic nature, or a soft earth, clay, or flookan, like a vein, which unheads and intersects the true lode

Cross-bars, round bars of iron bent at each end, used as levers to turn the shank of an anchor

Cross-chocks, pieces of timber fayed across the deadwood amidships, to make good the deficiency of the heels of the lower futtocks

Cross (*church*), or a Greek cross, that in which the length of the transverse part is equal to that of the nave; so called because most of the Greek churches were built in that form

Cross (*church*), or a Latin cross, that whose nave is longer than the cross part, as in most Gothic churches

Cross-grained stuff, in joinery, wood having its fibres running in contrary positions to the surfaces, and which consequently cannot be made perfectly smooth when planed in one direction, without turning it or turning the plane

Cross-heads, in locomotive engines, the part of the motion into which the piston-rod is fitted on the cy-

linder side and the connecting-rod attached on the driving wheel axle side

Cross-head guides, in locomotive engines, the parallel bars between which the cross-head moves in a right line with the cylinder and driving wheel axle: they are also called *motion bars*

Cross-head blocks, in locomotive engines, the parts which slide between the parallel guides. The ends of the cross-head are fitted into these blocks. The cross-head, cross-head guides, and block, constitute what is called 'the motion of the engine.'

Cross-head, in the steam engine, a cross-bar fixed centrally on the top of a piston-rod, and connected to the beam: its motion is confined to a direct line by guides at each end; or, in the side-lever and beam engines, by an apparatus called a 'parallel motion'

Cross-jack: the cross-jack yard is the lower yard on the mizen mast

Cross-spales, pieces of timber placed across a vessel, and nailed to the frames, to keep the sides together until the knees are bolted

Cross-somer, a beam of timber

Cross-springer, in groined vaulting, the rib which extends diagonally from one pier to another

Cross-trees, pieces of oak supported by the cheeks and trestle-trees at the mast-heads, to sustain the tops on the lower mast, and to spread the top-gallant rigging at the top-mast head

Cross vaulting is formed by the intersection of two or more simple vaults of arch-work

Croud, or *Crowde*, a crypt, or undercroft of a church

Crow, in mechanics, an iron lever, made with a sharp point at one end, and two claws at the other; used in heaving and purchasing great weights

Crow-foot, a number of small lines rove through to suspend an awning

Crown, in geometry, a plane ring included between two concentric perimeters, generated by the motion of part of a right line round the centre, to which the moving part is not contiguous

Crown of an anchor, the place where the arms are joined to the shank

Crown of an arch, that line or point upon its surface which is the highest or most elevated from its springing

Crown-post, the middle post of a trussed roof

Crown-wheels. Circular motion is communicated at right angles by means of teeth or cogs situated parallel to the axis of the wheel. Wheels thus formed are denominated 'crown' or 'contrate wheels:' they act either upon a common pinion or upon a lantern.

Crozier, the pastoral staff of a bishop or mitred abbot, having the head curled round somewhat in the manner of a shepherd's crook

Crucifix, a representation of our blessed Saviour on the cross

Crustæ, figures or images in low relief, embossed upon plate

Crustarius, an artist; an engraver for inlaid work, &c.

Crutch, a knee or piece of knee timber, placed inside a vessel to secure the heels of the cant-timbers abaft

Cryophorus, an instrument by which the freezing qualities of the atmosphere may be ascertained

Crypt, a vault beneath a building, either entirely or partly underground, frequently under churches and cathedrals

Crypta, or *Crypt*, among the Romans, any long narrow vault, whether wholly or partially below the level of the earth

Crypto Portico, an enclosed gallery or portico having a wall with openings or windows in it, instead of columns at the side

Ctesibica machina, a double-actioned forcing pump invented by Ctesibius of Alexandria

Cuare (Cornish), a quarry of stones

Cubature, the cubing of a solid, or measuring of the space comprehended in a solid, as in a cone, pyramid, cylinder, &c.

Cube, in geometry, a regular or solid body consisting of six square and six equal faces and sides, and its angles all right, and therefore equal

Cube, or *Hexahedron*, a solid regular body, consisting of six equal square sides

Cubes, or *Cube numbers* in arithmetic, and the theory of numbers, are those whose cube root is a complete integer; or they are numbers produced by multiplying a given number twice into itself, or by the multiplication of three equal factors

Cube root, of a number, say 8, the number which multiplied into itself twice will produce 8—namely, 2; or it is that number by which, if you divide a number twice, the quotient will be equal to itself

Cubic foot of water, what a vessel 1 foot square and 1 foot deep will hold

Cubicule, among the Romans, a bedchamber, tent, or balcony

Cubiculum, according to Pliny, a room furnished with a sofa or bed

Cubile, the ground-work or lowest course of stones in a building

Cubit, a measure used among the ancients, and which the Hebrews call 'amma,' the mother of other measures. A cubit was originally the distance from the elbow to the extremity of the middle finger; which is the fourth part of a well-proportioned man's stature.

Cubital, a bolster or cushion for the elbow to rest upon, for invalids

Cuboch, a name for the unit or integer of a power, being the effect produced by one cubic foot of water in one foot perpendicular descent

Cuckold's-neck, a knot by which a a rope is secured to a spar, the two parts of the rope crossing each other and seized together

Cuddy, a cabin in the fore part of a boat

Cullis, a gutter in a roof; any groove or channel

Culm, stone coal, resembling the Kilkenny coal of Ireland

Culmen, the roof of a house or church

Culverhouse, a dove-cot or pigeon-house

Culvert, an arched drain for the passage of water

Culvert, an arched passage or bridge beneath a road, canal, or railway

Culver-tail, to dove-tail

Cuneus, the division of the audience part of a theatre comprehended between two adjoining scalaria or staircases which lead from one præcinctio to another: so called from its form, which resembles a wedge. The foremost cunei were termed 'cavæ prima;' the middle, 'cavæ media;' and the uppermost, 'cavæ summa.' The whole of the audience part, exclusive of the orchestra, was likewise called 'cavæ.'

Cupboards answered in some respects to the sideboards of the present day. They were sometimes mere planched tops, resting on trestles, or fixed with legs against the wall; at others, framed on stages, rising one above another, and moveable: these were called 'joined cupboards,' occasionally carved, and, like tables, covered with carpets. At the marriage of Prince Arthur, son of Henry VII., in the hall was a triangular cupboard, five stages high, set with plate, valued at £1200, entirely ornamental; and in the "utter chamber," where the princess dined, was another cupboard, "set with gold plate, garnished with stone and pearl," and valued at £20,000.

Cupola, a small room, either circular or polygonal, standing on the top of a dome: by some it is called a lantern

Cupola, a spherical or spheroidal

covering to a building, or any part of it

Cup-valve, for a steam-engine: it resembles a conical valve, made to fit a cover in the form of a vase or of the portion of a sphere

Curia, in architecture; the building in which the highest council of the Roman state assembled, described by Vitruvius as being adjacent to the agora or forum

Curling-stuff, in joinery, that which is produced by the winding or coiling of the fibres round the boughs of a tree, when they begin to shoot out of the trunk

Current, a stream or flux of water in any direction. The setting of the current is that point of the compass towards which the waters run; and the drift of a current is the rate it runs per hour.

Curtilage, a term formerly applied to the division or boundary of manorial lands

Curve, in geometry, a line wherein the several points of which it consists tend several ways, or are posited towards different quarters

Curvilinear, consisting of curved lines

Cushion-capital, the capital of a column so sculptured as to resemble a cushion pressed down by the weight of its entablature

Cushions and *window-pillows* were, in Tudor times, stuffed—not unlike the woolsack of the lord chancellor—in round, square, and oblong shapes, covered with carpet-work, velvet, or embroidery; the family arms frequently supplying the device

Cusp, an ornament generally in Gothic windows or doors: it is to be found in the concave bends of stone-work

Cusps, projecting points forming the featherings or foliation in Gothic tracery, archery, panels, &c.

Cut, in mining, to intersect a vein, branch, or lode, by driving horizontally or sinking perpendicularly at right angles

Cutter, a small boat; also a kind of sloop

Cutting. Cutting instruments act in dividing bodies upon the same principle as the wedge. The blade of the instrument is in general a thin wedge, but the edge itself is usually much more obtuse.

Cutwater, in a ship, is the sharp part of the head under the beak or figure

Cycle, a round of time; a space in which the same revolution begins again; a periodical space of time

Cycle, lunar, a period of nineteen years

Cycle, solar, a period of twenty-eight years, after which the days of the month return to the same days of the week

Cyclograph, or *Arcograph*, an instrument for drawing arcs of circles without centres, used in architectural and engineering drawings when the centres are too distant to be conveniently accessible

Cycloidal curves are defined as follows: 1. When a circle is made to rotate on a rectilinear basis, the figure described on the plane of the basis by any point in the plane of the circle is called a trochoid: a circle concentric with the generating circle, and passing through the describing circle. 2. If the describing point is in the circumference of the rotating circle, the two circles coincide, and the curve is called a cycloid. 3. If a circular basis be substituted for a rectilinear one, the trochoid will become an epitrochoid, and the cycloid an epicycloid.

Cyclopian Architecture, a class of building supposed to have preceded the invention of the classic orders in Greece, and attributed to the Cyclopes

Cyclopean wall, the oldest example of mason-work in Italy: in town-walls only has this style of building been used. The history of its origin is obscure. A large irregular mass of stone, having three, four, five, or more sides, hewn only on the irregular sides to be built upon, begins a wall: to this mass others are added, the sides of which are

made to fit the irregular sides of the first block; and on these again others of similar forms are built in the same manner.

Cyclostylar, relating to a structure composed of a circular range of columns without a core; with a core, the range would be a peristyle

Cylinder, a body having two flat surfaces and one circular: for instance, a roller is a cylinder

Cylinder, a roller used for levelling and condensating the ground in agricultural and other operations

Cylinders, in steam engines, hollow cylindrical vessels: within the cylinder the steam exerts its power upon the piston, which, by means of its rod, transmits it to the other parts of the engine

Cylinders, in locomotive engines, hollow vessels, usually made of cast iron, and bored out accurately, into which pistons are fitted steam-tight, yet easily moveable by the pressure of the steam

Cylinder cocks, in steam engines, cocks placed in convenient parts of the cylinder for admitting oil to lubricate the piston, or by which to blow out the condensed steam, or any deposit in the cylinders

Cylinder cover, in steam engines, the lid bolted to a flanch round the top of a cylinder, so as to be perfectly steam-tight: it has a stuffing-box cast in the centre, through which the piston-rod alternates

Cylindrical vault, a vault without groins, resting upon two parallel walls

Cylindrical walling is that erected upon a circular plan, forming a cylinder, or a part less than a cylinder, according as the plan is an entire circumference or a less portion

Cyling, anciently *ceiling*.

Cyma, called also *cymatium*, its name arising from its resemblance to a wave; a moulding which is hollow in its upper part, and swelling below. There are two sorts,— the *Cyma recta*, just described, and the *Cyma reversa*, whose upper part swells, whilst the lower part is hollow.

Cymatium, a moulding whose section or profile is convex below and concave above, somewhat resembling the letter S

Cymophane, a mineral of a green colour, resembling the chrysoberyl

Cypress-tree, one of the evergreens; very proper to mix with pines and firs in forming clumps. The wood of the cypress is very valuable, when grown to a size fit for planks, which dimension it attains in as short a time as oak. It was much used by the ancients, and was employed in the original doors of St. Peter's at Rome, which, on being replaced, after six hundred years, by gates of brass, were found to be perfectly free from decay, and within to have retained part of the original odour of the wood.

Cyrtostyle, a circular projecting portico

Cyzicenus, anciently a hall decorated with sculpture

DAC

Dactylus, a Greek measure of length, the sixteenth part of an English foot

Dado, a term for the die or plane face of a pedestal. The dado employed in the interior of buildings is a continuous pedestal, with a plinth and base moulding, and a cornice or dado moulding surmounting the die.

DAD

Dado, the solid block or cube forming the body of a pedestal, in classical architecture, between the base mouldings and cornice; an architectural arrangement of mouldings, &c. round the lower part of the walls of a room

Dagger, in ship-building, a piece of timber that crosses all the poppets

of the bulge-ways, to keep them together: the plank that secures the heads of the poppets is called the *dagger-plank*

Dagger knees are lodging knees, with side arms cast down and bolted through the clamp: they are placed at the lower decks of some ships, instead of hanging knees, to preserve as much stowage in the hold as possible

Dairy-house, a place for keeping milk

Dais, in early domestic architecture, the chief seat at the high board or principal table (cross-table) in a baronial hall; also the principal table itself, and the raised part of the floor on which it is placed

Dais, a canopy to cover an altar, throne, or tribunal; the chief or upper table in a monastery

Dam, a bank or obstruction built across a river or stream, for the purpose of raising the level of the water on the upper side of it. Dams built for the purpose of inland navigation, or for that of securing a water power, may be considered as having a more permanent character.

Damascus steel, a sort of steel brought from the Levant, greatly esteemed for the manufacture of cutting instruments

Damasquine, a term applied to ornamental work of gold or silver, incrusted on iron or steel

Damonico or *Monicon*, an iron ochre, being a compound of terra di sienna and Roman ochre, burnt, and having all their qualities: it is rather more russet in hue than the orange de Mars, has considerable transparency, is rich and durable in colour, and affords good flesh tints

Damper, a valve placed in a chimney, to diminish the draught when the heat is too intense

Damper, in locomotive engines, a kind of iron Venetian blind, fixed to the smoke-box end of the boiler, in front of the tubes: it is shut down when the engine is standing, and *thus stops the* draught and economizes fuel; but it is opened when the engine is running

Damps: various kinds of permanently elastic fluids generated in mines are thus named by the miners: choke-damps consist mostly of carbonic acid gas, and fire-damps of carburetted hydrogen gas

Dancette, in heraldry, zigzag or chevron fret; seen in Norman buildings

Data useful in various calculations of the properties of materials. [The data correspond to the mean temperature and pressure of the atmosphere; the materials are assumed to be dry, and the temperature is measured by Fahrenheit's scale.]

Air. Specific gravity, 0·0012; weight of a cubic foot, 0·0753 lb., or 527 grains (Shuckburgh); 13·3 cubic feet, or 17 cylindric feet of air, weigh 1 lb.; it expands $\frac{1}{480}$ or ·00208 of its bulk at 32° by the addition of one degree of heat (Dulong and Petit).

Ash. Specific gravity, 0·76; weight of a cubic foot, 47·5 lbs.; weight of a bar 1 foot long and 1 inch square, 0·33 lb.; will bear without permanent alteration a strain of 3540 lbs. upon a square inch, and an extension of $\frac{1}{484}$ of its length; weight of modulus of elasticity for a base of an inch square, 1,640,000 lbs.; height of modulus of elasticity, 4,970,000 feet; modulus of resilience, 7·6; specific resilience, 10. (Calculated from Barlow's experiments.)

Compared with cast iron as unity, its strength is 0·23; its extensibility, 2·6; and its stiffness, 0·089.

Atmosphere. Mean pressure of, at London, 28·89 inches of mercury = 14·18 lbs. upon a square inch. (Royal Society.) The pressure of the atmosphere is usually estimated at 30 inches of mercury, which is very nearly 14¾ lbs. upon a square inch, and equivalent to a column of water 34 feet high.

Beech. Specific gravity, 0·696; weight of a cubic foot, 45·3 lbs.;

weight of a bar 1 foot long and 1 inch square, 0·315 lb.; will bear without permanent alteration on a square inch, 2360 lbs., and an extension of $\frac{1}{370}$ of its length; weight of modulus of elasticity for a base of an inch square, 1,345,000 lbs.; height of modulus of elasticity, 4,600,000 feet; modulus of resilience, 4·14; specific resilience, 6. (Calculated from Barlow's Experiments.)

Compared with cast iron as unity, its strength is 0·15; its extensibility, 2·1; and its stiffness, 0·073.

Brass, *cast*. Specific gravity, 8·37; weight of a cubic foot, 523 lbs.; weight of a bar 1 foot long and 1 inch square, 3·63 lbs.; expands $\frac{1}{53800}$ of its length by one degree of heat (Troughton); melts at 1869° (Daniell); cohesive force of a square inch, 18,000 lbs. (Rennie); will bear on a square inch without permanent alteration, 6700 lbs., and an extension in length of $\frac{1}{1333}$; weight of modulus of elasticity for a base of an inch square, 8,930,000 lbs.; height of modulus of elasticity, 2,460,000 feet; modulus of resilience, 5; specific resilience, 0·6 (Tredgold).

Compared with cast iron as unity, its strength is 0·435; its extensibility, 0·9; and its stiffness, 0·49.

Brick. Specific gravity, 1·841; weight of a cubic foot, 115 lbs.; absorbs $\frac{1}{15}$ of its weight of water; cohesive force of a square inch, 275 lbs. (Tredgold); is crushed by a force of 562 lbs. on a square inch (Rennie.)

Brick-work. Weight of a cubic foot of newly built, 117 lbs.; weight of a rod of new brick-work, 16 tons.

Bridges. When a bridge is covered with people, it is about equivalent to a load of 120 lbs. on a superficial foot; and this may be esteemed the greatest possible extraneous load that can be collected on a bridge; while one incapable of supporting this load cannot be deemed safe.

Bronze. See *Gun-metal*.

Cast Iron. Specific gravity, 7·207; weight of a cubic foot, 450 lbs.; a bar 1 foot long and 1 inch square weighs 3·2 lbs. nearly; it expands $\frac{1}{18000}$ of its length by one degree of heat (Roy); greatest change of length in the shade in this climate, $\frac{1}{1723}$; greatest change of length when exposed to sun's rays, $\frac{1}{1270}$; melts at 3479° (Daniell), and shrinks in cooling from $\frac{1}{98}$ to $\frac{1}{85}$ of its length (Muschet); is crushed by a force of 93,000 lbs. upon a square inch (Rennie); will bear without permanent alteration, 15,300 lbs. upon a square inch, and an extension of $\frac{1}{1204}$ of its length; weight of modulus of elasticity for a base 1 inch square, 18,400,000 lbs.; height of modulus of elasticity, 5,750,000 feet; modulus of resilience, 12·7; specific resilience, 1·76 (Tredgold).

Chalk. Specific gravity, 2·315; weight of a cubic foot, 144·7 lbs.; is crushed by a force of 500 lbs. on a square inch. (Rennie.)

Clay. Specific gravity, 2·0; weight of a cubic foot, 125 lbs.

Coal, *Newcastle*. Specific gravity, 1·269; weight of a cubic foot, 79·31 lbs. A London chaldron of 36 bushels weighs about 28 cwt., whence a bushel is 87 lbs. (but is usually rated at 84 lbs.) A Newcastle chaldron, 53 cwt. (Smeaton.)

Copper. Specific gravity, 8·75 (Hatchett); weight of a cubic foot, 549 lbs.; weight of a bar 1 foot long and 1 inch square, 3·81 lbs.; expands in length by one degree of heat, $\frac{1}{105900}$ (Smeaton); melts at 2548° (Daniell); cohesive force of a square inch, when hammered, 33,000 lbs. (Rennie).

Earth, *common*. Specific gravity, 1·52 to 2·00; weight of a cubic foot, from 95 to 125 lbs.

Elm. Specific gravity, 0·544; weight of a cubic foot, 34 lbs.;

weight of a bar 1 foot long and 1 inch square, 0·236 lb.; will bear on a square inch without permanent alteration, 3240 lbs., and an extension in length of $\frac{1}{414}$; weight of modulus of elasticity for a base of an inch square, 1,340,000 lbs.; height of modulus of elasticity, 5,680,000 feet; modulus of resilience, 7·87; specific resilience, 14·4. (Calculated from Barlow's Experiments.)

Compared with cast iron as unity, its strength is 0·21; its extensibility, 2·9; and its stiffness, 0·073.

Fir, *red* or *yellow*. Specific gravity, 0·557; weight of a cubic foot, 34·8 lbs.; weight of a bar 1 foot long and 1 inch square, 0·242 lb.; will bear on a square inch without permanent alteration, 4290 lbs. = 2 tons nearly, and an extension in length of $\frac{1}{470}$; weight of modulus of elasticity for a base of an inch square, 2,016,000 lbs.; height of modulus of elasticity, 8,330,000 feet; modulus of resilience, 9·13; specific resilience, 16·4. (Tredgold.)

Compared with cast iron as unity, its strength is 0·3; its extensibility, 2·6, and its stiffness, 0·1154, $= \frac{1}{8 \cdot 66}$.

Fir, *white*. Specific gravity, 0·47; weight of a cubic foot, 29·3 lbs.; weight of a bar 1 foot long and 1 inch square, 0·204 lb.; will bear on a square inch without permanent alteration, 3630 lbs., and an extension in length of $\frac{1}{504}$; weight of modulus of elasticity for a base of an inch square, 1,830,000 lbs.; height of modulus of elasticity, 8,970,000 feet; modulus of resilience, 7·2; specific resilience, 15·3. (Tredgold.)

Compared with cast iron as unity, its strength is 0·23; its extensibility, 2·4; and its stiffness, 0·1.

Floors. The weight of a superficial foot of a floor is about 40 lbs. when there is a ceiling, counter-*floor*, and iron girders. When a *floor is covered* with people, the load upon a superficial foot may be calculated at 120 lbs.: therefore, 120 + 40 = 160 lbs. on a superficial foot is the least stress that ought to be taken in estimating the strength for the parts of a floor of a room.

Force. See *Gravity*, *Horse*, &c.

Granite, *Aberdeen*. Specific gravity, 2·625; weight of a cubic foot, 164 lbs.; is crushed by a force of 10·910 lbs. upon a square inch. (Rennie.)

Gravel. Weight of a cubic foot, about 120 lbs.

Gravity generates a velocity of $32\frac{1}{6}$ feet in a second in a body falling from rest; space described in the first second, $16\frac{1}{12}$ feet.

Gun-metal, *cast* (copper 8 parts, tin 1). Specific gravity, 8·153; weight of a cubic foot, $509\frac{1}{2}$ lbs.; weight of a bar 1 foot long and 1 inch square, 3·54 lbs. (Tredgold); expands in length by 1° of heat, $\frac{1}{99090}$ (Smeaton); will bear on a square inch without permanent alteration, 10,000 lbs., and an extension in length of $\frac{1}{960}$; weight of modulus of elasticity for a base 1 inch square, 9,873,000 lbs.; height of modulus of elasticity, 2,790,000 feet; modulus of resilience, and specific resilience, not determined (Tredgold).

Compared with cast iron as unity, its strength is 0·65; its extensibility, 1·25; and its stiffness, 0·535.

Horse, of average power, produces the greatest effect in drawing a load when exerting a force of $187\frac{1}{2}$ lbs. with a velocity of $2\frac{1}{2}$ feet per second, working 8 hours in a day. (Tredgold.) A good horse can exert a force of 480 lbs. for a short time. (Desaguliers.) In calculating the strength for horse machinery, the horse's power should be considered 400 lbs.

Iron, *cast*. See *Cast Iron*.

Iron, *malleable*. Specific gravity, 7·6 (Muschenbroëk); weight of a cubic foot, 475 lbs.; weight of a bar 1 foot long and 1 inch square,

3·3 lbs.; ditto, when hammered, 3·4 lbs.; expands in length by 1° of heat, $\frac{1}{149000}$ (Smeaton); good English iron will bear on a square inch without permanent alteration, 17,800 lbs. = 8 tons nearly, and an extension in length of $\frac{1}{1400}$; cohesive force diminished $\frac{1}{3000}$ by an elevation 1° of temperature; weight of modulus of elasticity for a base of an inch square, 24,920,000 lbs.; height of modulus of elasticity, 7,550,000 feet; modulus of resilience, and specific resilience, not determined (Tredgold).

Compared with cast iron as unity, its strength is 1·12; its extensibility, 0·86; and its stiffness, 1·3.

Larch. Specific gravity, ·560; weight of a cubic foot, 35 lbs.; weight of a bar 1 foot long and 1 inch square, 0·243 lb.; will bear on a square inch without permanent alteration, 2065 lbs., and an extension in length of $\frac{1}{350}$; weight of modulus of elasticity for a base of an inch square, 10,074,000 lbs.; height of modulus of elasticity, 4,415,000 feet; modulus of resilience, 4; specific resilience, 7·1. (Calculated from Barlow's Experiments.)

Compared with cast iron as unity, its strength is 0·136; its extensibility, 2·3; and its stiffness, 0·058.

Lead, *cast*. Specific gravity, 11·353 (Brisson); weight of a cubic foot, 709·5 lbs.; weight of a bar 1 foot long and 1 inch square, 4·94 lbs.; expands in length by 1° degree of heat, $\frac{1}{39800}$ (Smeaton); melts at 612° (Crichton); will bear on a square inch without permanent alteration, 1500 lbs., and an extension in length of $\frac{1}{480}$; weight of modulus of elasticity for a base 1 inch square, 720,000 lbs.; height of modulus of elasticity, 146,000 feet; modulus of resilience, 3·12; specific resilience, 0·27 (Tredgold).

Compared with cast iron as unity, its strength is 0·096; its extensibility, 2·5; and its stiffness, 0·0385.

Mahogany, *Honduras*. Specific gravity, 0·56; weight of a cubic foot, 35 lbs.; weight of a bar 1 foot long and 1 inch square, 0·243 lb.; will bear on a square inch without permanent alteration, 3800 lbs., and an extension in length of $\frac{1}{490}$; weight of modulus of elasticity for a base 1 inch square, 1,596,000 lbs.; height of modulus of elasticity, 6,570,000 feet; modulus of resilience, 9·047; specific resilience, 16·1. (Tredgold.)

Compared with cast iron as unity, its strength is 0·24; its extensibility, 2·9; and its stiffness, 0·487.

Man. A man of average power produces the greatest effect when exerting a force of 31¼ lbs. with a velocity of 2 feet per second, for 10 hours in a day. (Tredgold.) A strong man will raise and carry from 250 to 300 lbs. (Desaguliers.)

Marble, *white*. Specific gravity, 2·706; weight of a cubic foot, 169 lbs.; weight of a bar 1 foot long and 1 inch square, 1·17 lb.; cohesive force of a square inch, 1811 lbs.; extensibility, $\frac{1}{1394}$ of its length; weight of modulus of elasticity for a base of an inch square, 2,520,000 lbs.; height of modulus of elasticity, 2,150,000 feet; modulus of resilience at the point of fracture, 1·3; specific resilience at the point of fracture, 0·48 (Tredgold); is crushed by a force of 6060 lbs. upon a square inch (Rennie).

Mercury. Specific gravity, 13·568 (Brisson); weight of a cubic inch, 0·4948 lb.; expands in bulk by 1° of heat, $\frac{1}{5550}$ (Dulong and Petit); weight of modulus of elasticity for a base of an inch square, 4,417,000 lbs.; height of modulus of elasticity, 750,000 feet (Dr. Young, from Canton's Experiments).

Oak, *good English*. Specific gravity, 0·83; weight of a cubic foot, 52 lbs.; weight of a bar 1 foot long and 1 inch square, 0·36 lb.; will bear upon a square inch with-

out permanent alteration, 3960 lbs., and an extension in length of $\frac{1}{480}$; weight of modulus of elasticity for a base 1 inch square, 1,700,000 lbs.; height of modulus of elasticity, 4,730,000 feet; modulus of resilience, 9·2; specific resilience, 11. (Tredgold.)

Compared with cast iron as unity, its strength is 0·25; its extensibility, 2·8; and its stiffness, 0·093.

PENDULUM. Length of pendulum to vibrate seconds in the latitude of London, 39·1372 inches (Kater); ditto to vibrate half-seconds, 9·7843 inches.

PINE, *American yellow.* Specific gravity, 0·46; weight of a cubic foot, 26¾ lbs.; weight of a bar 1 foot long and 1 inch square, 0·186 lb.; will bear on a square inch without permanent alteration, 3900 lbs., and an extension in length of $\frac{1}{414}$; weight of modulus of elasticity for a base of an inch square, 1,600,000 lbs.; height of modulus of elasticity, 8,700,000 feet; modulus of resilience, 9·4; specific resilience, 20. (Tredgold.)

Compared with cast iron as unity, its strength is 0·25; its extensibility, 2·9; and its stiffness, 0·087.

PORPHYRY, *red.* Specific gravity, 2·871; weight of a cubic foot, 179 lbs.; is crushed by a force of 35,568 lbs. upon a square inch. (Gauthey.)

ROPE, *hempen.* Weight of a common rope 1 foot long and 1 inch in circumference, from 0·04 to 0·46 lb.; and a rope of this size should not be exposed to a strain greater than 200 lbs.; but in compounded ropes, such as cables, the greatest strain should not exceed 120 lbs.; and the weight of a cable 1 foot in length and 1 inch in circumference does not exceed 0·027 lb. The square of the circumference in inches multiplied by *200 will* give the number of pounds *a rope may be* loaded with; and multiply by 120 instead of 200 for cables. Common ropes will bear a greater load with safety after they have been some time in use, in consequence of the tension of the fibres becoming equalized by repeated stretchings and partial untwisting. It has been imagined that the improved strength was gained by their being laid up in store; but if they can there be preserved from deterioration, it is as much as can be expected.

ROOFS. Weight of a square foot of Welsh rag slating, 11¼ lbs.; weight of a square foot of plain tiling, 16¼ lbs.; greatest force of the wind upon a superficial foot of roofing may be estimated at 40 lbs.

SLATE, *Welsh.* Specific gravity, 2·752 (Kirwan); weight of a cubic foot, 172 lbs.; weight of a bar 1 foot long and 1 inch square, 1·19 lb.; cohesive force of a square inch, 11,500 lbs.; extension before fracture, $\frac{1}{1870}$; weight of modulus of elasticity for a base of an inch square, 15,800,000 lbs.; height of modulus of elasticity, 13,240,000 feet; modulus of resilience, 8·4; specific resilience, 2 (Tredgold).

SLATE, *Westmoreland.* Cohesive force of a square inch, 7870 lbs.; extension in length before fracture, $\frac{1}{1640}$; weight of modulus of elasticity for a base of an inch square, 12,900,000 lbs. (Tredgold).

SLATE, *Scotch.* Cohesive force of a square inch, 9600 lbs.; extension in length before fracture, $\frac{1}{1645}$; weight of modulus of elasticity for a base 1 inch square, 15,790,000 lbs. (Tredgold).

STEAM. Specific gravity at 212° is to that of air at the mean temperature as 0·472 is to 1 (Thomson); weight of a cubic foot, 249 grains; modulus of elasticity for a base of an inch square, 14¾ lbs.; when not in contact with water, expands $\frac{1}{480}$ of its bulk by 1° of heat (Gay-Lussac).

STEEL. Specific gravity, 7·84; weight of a cubic foot, 490 lbs.; a bar 1 foot long and 1 inch square

weighs 3·4 lbs.; it expands in length by 1° of heat, $\frac{1}{157500}$ (Roy); tempered steel will bear without permanent alteration, 45,000 lbs.; cohesive force of a square inch, 130,000 lbs. (Rennie); cohesive force diminished $\frac{1}{5000}$ by elevating the temperature 1°; modulus of elasticity for a base of an inch square, 29,000,000 lbs.; height of modulus of elasticity, 8,530,000 feet (Dr. Young).

Stone, *Portland*. Specific gravity, 2·113; weight of a cubic foot, 132 lbs.; weight of a prism 1 inch square and 1 foot long, 0·92 lb.; absorbs $\frac{1}{18}$ of its weight of water (R. Tredgold); is crushed by a force of 3729 lbs. upon a square inch (Rennie); cohesive force of a square inch, 857 lbs.; extends before fracture $\frac{1}{1788}$ of its length; modulus of elasticity for a base of an inch square, 1,533,000 lbs.; height of modulus of elasticity, 1,672,000 feet; modulus of resilience at the point of fracture, 0·5; specific resilience at the point of fracture, 0·23 (Tredgold).

Stone, *Bath*. Specific gravity, 1·975; weight of a cubic foot, 123·4 lbs.; absorbs $\frac{1}{13}$ of its weight of water (R. Tredgold); cohesive force of a square inch, 478 lbs. (Tredgold).

Stone, *Craigleith*. Specific gravity, 2·362; weight of a cubic foot, 147·6 lbs.; absorbs $\frac{1}{83}$ of its weight of water; cohesive force of a square inch, 772 lbs. (Tredgold); is crushed by a force of 5490 lbs. upon a square inch (Rennie).

Stone, *Dundee*. Specific gravity, 2·621; weight of a cubic foot, 163·8 lbs.; absorbs $\frac{1}{511}$ part of its weight of water; cohesive force of a square inch, 2661 lbs. (Tredgold); is crushed by a force of 6630 lbs. upon a square inch (Rennie).

Stone-work. Weight of a cubic foot of rubble-work, about 140 lbs.; of hewn stone, 160 lbs.

Tin, *cast*. Specific gravity, 7·291 (Brisson); weight of a cubic foot, 455·7 lbs.; weight of a bar 1 foot long and 1 inch square, 3·165 lbs.; expands in length by 1° of heat, $\frac{1}{12510}$ (Smeaton); melts at 442° (Crichton); will bear upon a square inch without permanent alteration, 2880 lbs., and an extension in length of $\frac{1}{1600}$; modulus of elasticity for a base of an inch square, 4,608,000; height of modulus of elasticity, 1,453,000 feet; modulus of resilience, 1·8; specific resilience, 0·247 (Tredgold).

Compared with cast iron as unity, its strength is 0·182; its extensibility, 0·75; and its stiffness, 0·25.

Water, *river*. Specific gravity, 1·000; weight of a cubic foot, 62·5 lbs.; weight of a cubic inch, 252·525 grains; weight of a prism 1 foot long and 1 inch square, 0·434 lb.; weight of an ale gallon of water, 10·2 lbs.; expands in bulk by 1° of heat, $\frac{1}{3858}$ (Dalton); expands, in freezing, $\frac{1}{17}$ of its bulk (Williams); and the expanding force of freezing water is about 35,000 lbs. upon a square inch, according to Muschenbroëk's valuation; modulus of elasticity for a base of an inch square, 326,000 lbs.; height of modulus of elasticity, 750,000 feet, or 22,100 atmospheres of 30 inches of mercury (Dr. Young, from Canton's Experiments).

Water has a state of maximum density at or near 40°, which is considered an exception to the general law of expansion by heat: it is extremely improbable that there is any thing more than an apparent exception, most likely arising from water at low temperatures absorbing a considerable quantity of air, which has the effect of expanding it, and consequently of causing the apparent anomaly.

Water, *sea*. Specific gravity, 1·0271; weight of a cubic foot, 64·2 lbs.

Water is 828 times the density of air of the temperature 60°, and barometer 30.

Whale-bone. Specific gravity,

1·3; weight of a cubic foot, 81 lbs.; will bear a strain of 5600 lbs. upon a square inch without permanent alteration, and an extension in length of $\frac{1}{148}$; modulus of elasticity for a base of an inch square, 820,000 lbs.; height of modulus of elasticity, 1,458,000 feet; modulus of resilience, 38·3; specific resilience, 29. (Tredgold.)

WIND. Greatest observed velocity, 159 feet per second (Rochon); force of wind with that velocity, about 57¾ lbs. on a square foot.

ZINC, *cast*. Specific gravity, 7·028 (Watson); weight of a cubic foot, 439¼ lbs.; weight of a bar 1 inch square and 1 foot long, 3·05 lbs.; expands in length by 1° of heat, $\frac{1}{61200}$ (Smeaton); melts at 648° (Daniell); will bear on a square inch without permanent alteration, 5700 lbs. = 0·365 cast iron, and an extension in length of $\frac{1}{9400}$ = ⅓ that of cast iron (Tredgold); modulus of elasticity for a base of an inch square, 13,680,000 lbs.; height of modulus of elasticity, 4,480,000 feet; modulus of resilience, 2·4; specific resilience, 0·34 (Tredgold).

Compared with cast iron as unity, its strength is 0·365; its extensibility, 0·5; and its stiffness, 0·76

Data, a term for such facts, things, or quantities as are given or known, in order thereby to find other things that are unknown

Davit, in navigation, a short boom fitted in the fore channel, to hoist the flukes of the anchor to the bow, which is called 'fishing the anchor'

Day or *Bay*, in architecture, one of the lights or compartments between mullion and mullion, in the great windows of the pointed style

Days, in early domestic architecture, the bay or lights of a window; the spaces between the mullions

Dead colouring is the first layer of colours, consisting usually of some shade of grey. Its design is to *receive and preserve* the finishing *colours; and it* is called dead because it is not seen when is completed

Dead doors, in ship building the outside of the quarte doors, in case the quarte should be carried away

Dead eyes, fixed in the chanr three holes to receive the of the shrouds

Deadflat, the name of a midsl

Dead lights, in navigation, shutters for the cabin which are fastened on v sea runs high

Dead reckoning, the estimati seamen make of the ship by keeping an account of by the log, by the course and by rectifying the who lowance for drift, leeway,

Dead shore, a piece of timbe up in brick-work, to supp perincumbent mass until t work which is to carry it h become hard

Dead water, the eddy wate diately at the stern of a sl under way

Dead wood, pieces of timb on the keel to seat the bers on afore and abaft tl and continued as high as th down of the floors

Deafening sound boarding, the used to prevent the passage through wooden partitions

Deam, a door-post, or thres conceal, or shut up

Deambulatory, an ambulatory ter for exercise; also the a church, or the portico the body of a church

Debacle, a great aqueous t breaking up and transpor sive rocks and gravel by mous rush of water

Debris, fragments of rocks, gravel, sand, trunks of tr detached from the sum sides of mountains by the the elements

Decade, the sum of ten

Decagon, in geometry, a pla of ten sides

Decalogue, the Ten Commandments delivered to the Israelites from Mount Sinai, in which the moral law is summarily comprehended. The Jews call these precepts 'The Ten Words.'* In the building of new churches, and in the restoration of those of olden times, a proper and effective style of painting and embellishing the words of the ten commandments in face of the altar has been introduced.

Decanicum, an ecclesiastical prison

Decastyle, in architecture: a temple is said to be decastyle when its portico contains ten columns in a line

Decastyle, a portico consisting of ten columns in front

Decempeda, a ten-foot rod employed by architects and surveyors for taking measurements

Decemremis, a vessel with ten banks of oars on a side

Decimal, the tenth part

Deck, the floor of a ship

Decoration, the combination of ornamental objects which are employed in great variety, principally for the interior and exterior of all kinds of edifices, and for purposes of art generally. Decoration, when judiciously introduced, becomes in many instances a language, intelligible only, however, when the artist is capable of speaking it correctly and the spectator of comprehending it. It is then a system of hieroglyphic writing, and the building to which it is applied becomes historical, and tells its tale more nobly and appropriately than it can ever do through the undignified medium of mural inscriptions. Nothing can be more judicious or appropriate than the sculpture in the metopes and pediment of the Parthenon. Ornament here not only creates a variety on the surface of the work, but relates, by the aid of the sculptor, a history intimately connected with the religious and moral destination of the edifice to which it is applied.

Decorative style of Gothic Architecture: first introduced in the reign of Edward I., it was matured in England, and prevailed during the greater part of the 14th century. Its distinguishing features, says Dr. Whewell, are characterized by its window-tracery, geometrical in the early instances, flowing in the later; but also, and perhaps better, by its triangular canopies, crocketed and finialed; its niched buttresses, with triangular heads; its peculiar mouldings, no longer a collection of equal rounds, with hollows like the early English, but an assemblage of various members, some broad, some narrow, beautifully grouped and proportioned. A capital with crumpled leaves, a peculiar base and pedestal, also belong to this style.

Definitions in geometry:

1. A point is that which hath no parts, or which hath no magnitude.

2. A line is length without breadth.

3. A superficies has length and breadth.

4. A solid is a figure of three dimensions, having length, breadth, and thickness. Hence surfaces are extremities of solids, and lines the extremities of surfaces, and points the extremities of lines.

If two lines will always coincide, however applied, when any two points in the one coincide with the two points in the other, the two lines are called straight lines, or otherwise right lines.

A curve continually changes its direction between its extreme points, or has no part straight.

Parallel lines are always at the same distance, and will never meet, though ever so far produced. Oblique right lines change their dis-

* To these the Saviour added another: "A new commandment I give unto you, That ye love one another; as I have loved you, that ye also love one another." (John xiii. 34.)

tance, and would meet, if produced.

One line is perpendicular to another when it inclines no more to one side than another.

A straight line is a tangent to a circle when it touches the circle without cutting, when both are produced.

An angle is the inclination of two lines towards one another in the same plane, meeting in a point.

Angles are either right, acute, or oblique.

A right angle is that which is made by one line perpendicular to another, or when the angles on each side are equal.

An acute angle is less than a right angle.

An obtuse angle is greater than a right angle.

A plane is a surface with which a straight line will every where coincide; and is otherwise called a straight surface.

Plane figures, bounded by right lines, have names according to the number of their sides, or of their angles, for they have as many sides as angles: the least number is three.

An equilateral triangle is that whose three sides are equal.

An isosceles triangle has only two sides equal.

A scalene triangle has all sides unequal.

A right-angled triangle has only one right angle.

Other triangles are oblique-angled, and are either obtuse or acute.

An acute-angled triangle has all its angles acute.

An obtuse-angled triangle has one obtuse angle.

A figure of four sides, or angles, is called a quadrilateral, or quadrangle.

A parallelogram is a quadrilate ral, which has both pairs of its *opposite* sides parallel, and takes *the following* particular names:

A rectangle is a parallelogram, having all its angles right ones.

A square is an equilateral rectangle, having all its sides equal, and all its angles right angles.

A rhombus is an equilateral parallelogram whose angles are oblique

A rhomboid is an oblique-angled parallelogram, and its opposite sides only are equal.

A trapezium is a quadrilateral, which has neither pair of its sides parallel.

A trapezoid hath only one of its sides parallel.

Plane figures, having more than four sides, are in general called polygons, and receive other particular names according to the number of their sides or angles.

A pentagon is a polygon of five sides, a hexagon of six sides, a heptagon seven, an octagon eight, an enneagon nine, a decagon ten, an undecagon eleven, and a dodecagon twelve sides.

A regular polygon has all its sides and its angles equal; and if they are not equal, the polygon is irregular.

An equilateral triangle is also a regular figure of three sides, and a square is one of four; the former being called a trigon, and the latter a tetragon.

A circle is a plane figure, bounded by a curve line, called the circumference, which is every where equidistant, from a certain point within, called its centre.

The radius of a circle is a right line drawn from the centre to the circumference.

A diameter of a circle is a right line drawn through the centre, terminating on both sides of the circumference.

An arc of a circle is any part of the circumference.

A chord is a right line joining the extremities of an arc.

A segment is any part of a circle bounded by an arc and its chord.

A semicircle is half a circle, or a segment cut off by the diameter.

A sector is any part of a circle bounded by an arc, and two radii drawn to its extremities.

A quadrant, or quarter of a circle, is a sector having a quarter part of the circumference for its arc, and the two radii perpendicular to each other.

The height or altitude of any figure is a perpendicular let fall from an angle or its vertex to the opposite side, called the base.

The measure of any right-lined angle is an arc of any circle contained between the two lines which form the angle, the angular point being the centre.

A solid is said to be cut by a plane when it is divided into two parts, of which the common surface of separation is a plane, and this plane is called a section.

Definitions of solids:

A prism is a solid, the ends of which are similar and equal parallel planes and the sides parallelograms.

If the ends of the prism are perpendicular to the sides, the prism is called a right prism.

If the ends of the prism are oblique to the sides, the prism is called an oblique prism.

If the ends and sides are equal squares, the prism is called a cube.

If the base or ends are parallelograms, the solid is called a parallelopiped.

If the bases and sides are rectangles, the prism is called a rectangular prism.

If the ends are circles, the prism is called a cylinder.

If the ends or bases are ellipses, the prism is called a cylindroid.

A solid, standing upon any plane figure for its base, the sides of which are plane triangles, meeting in one point, is called a pyramid.

The solid is denominated from its base, as a triangular pyramid is one upon a triangular base, a square pyramid one upon a square base, &c.

If the base is a circle or an ellipsis, then the pyramid is called a cone.

If a solid be terminated by two dissimilar parallel planes as ends, and the remaining surfaces joining the ends be also planes, the solid is called a prismoid.

If a part of a pyramid next to the vertex be cut off by a plane parallel to the base, the portion of the pyramid contained between the cutting plane and the base is called the frustrum of a pyramid.

A solid, the base of which is a rectangle, the four sides joining the base plane surfaces, and two opposite ones meeting in a line parallel to the base, is called a cuneus or wedge.

A solid terminated by a surface which is every where equally distant from a certain point within it is called a sphere or globe.

If a sphere be cut by any two planes, the portion contained between the planes is called a zone, and each of the parts contained by a plane and the curved surface is called a segment.

If a semi-ellipsis, having an axis for its diameter, be revolved round this axis until it come to the place whence the motion began, the solid formed by the circumvolution is called a spheroid.

If the spheroid be generated round the greater axis, the solid is called a prolate spheroid.

If the solid be generated round the lesser axis, the solid is called an oblate spheroid.

A solid of any of the above structures, hollow within, so as to contain a solid of the same structure, is called a hollow solid

Deflagrator, an instrument for producing intense light and heat

Deflection, a term applied to the distance by which a curve departs from another curve, or from a straight line

Deflection, the deviation of a ship from its course

Degree, the 360th part of the circumference of a circle; 60 geographical miles

Degree, consisting of three figures of three places, comprehending units, tens, and hundreds

Deliquiæ, according to Vitruvius, gutters, or drains

Delivery valve, the upper valve in the air-pump, or that through which the water is lifted into the hot well; also used when speaking of any sort of pump

Delphica, a table made of marble or bronze, and resembling a tripod

Delubrum, a font or baptismal basin

Delubrum, in antiquity, a church, chapel, temple, or consecrated place

Delubrum, that part of a Roman temple in which the altar or statue of the deity was erected

Demesne, lands belonging to the lord of a manor, and which are contiguous to the manor-house

Demi-relievo, in sculpture, half-raised figures from the plane, as if cut in two, and only half fixed to the plane

Demi-tint is that shade seen when the sun shines on a house, or any other object, making an angle of nearly 45° on the ground plane, or when it shines more on the front than on the end.

Dendrometer, an instrument for the measuring of trees

Denticulus, a member in the Ionic and Corinthian entablatures, occuring between the zophorus and corona, and properly speaking, a part of the latter: so called because it represents denticuli, or small teeth, placed at equal intervals apart

Dentils, ornaments resembling teeth, used in the bed-mouldings of Ionic, Corinthian, and Composite cornices

Departure, in navigation, is the easting or westing of a ship with respect to the meridian from which *it departed* or sailed; or it is the *difference of longitude* between the present meridian and where the last reckoning was made

Depression of the pole, in navigation: so many degrees as you sail from the pole towards the equator, so many you are said to depress the pole, because it becomes so much lower in the horizon

Derrick, a Cornish word for a miner

Derrick, in navigation, a tackle used at the outer quarters of the mizen-yard; it also signifies a prop or support to sheers, &c.

Derrick. Sheers and Gyn have one object in common,—to find a point or fulcrum in space to which the pulley, in the shape of block and tackle, is to be supplied; and this is effected by the above, on one, two, and three legs, respectively. In the derrick and sheers, stability is given by guys; in the gyn, they are unnecessary. Wherever these guys are used, great attention must be paid to their being well fixed, or being (when requisite) duly eased-off: when accidents occur from neglect in this respect, they are generally very severe.

Describent, in geometry, is the line or surface from the motion of which a surface or body is supposed to be generated or described

Descriptive geometry: the application of geometrical rules to the representation of the figures and the various relations of the forms of bodies, in accordance to forms applicable to civil, military, and naval architecture, civil and mechanical engineering, and the other arts that require more correct scientific representations than have hitherto been afforded to the student

Desiccation, the chemical operation of drying bodies, sometimes effected by drying in the air, sometimes in warm chambers, by the air-pump, &c.

Design, a term in the fine arts, is employed first to signify the art of drawing or representing in lines the form of any object; next it expresses that combination of inven-

tion and purpose which enables the artist to compose a picture or a group, without reference to the material in which it is executed

Destina, according to Vitruvius, a column or pillar to support an edifice

Device, an emblem or ensign formerly borne on shields or embroidered upon banners as a cognizance; contemporary, in the history of heraldry, with coat armour itself

Device, in heraldry, painting, &c., any emblem used to represent a certain family, person, action, or quality, with a suitable motto, applied in a figurative sense

Dexter, in heraldry, an appellation given to whatever belongs to the right side of a shield or coat of arms, as the bend dexter, dexter point, &c.

Diagonal, a line drawn from angle to angle

Diagonal rib, a projecting band of stone or timber passing diagonally from one angle of a vaulted ceiling across the centre to the opposite angle

Diagonal scale. Equidistant parallel lines cut all lines drawn across them into equal parts; consequently a set of equidistant parallels laid down upon a ruler, with oblique lines of various lengths drawn across them, give with the compasses the means of immediately taking off various proportions of those lines.

Diagram, a delineation of geometrical figures; a mathematical illustration

Dial, an instrument for the measuring of time; not mentioned in Scripture before the reign of Ahaz, A.M. 3262. It is not clearly ascertained, even after this time, how the Jews divided the time by hours. The word hour occurs first in Tobit, which may confirm the opinion that the invention of dials came from beyond the Euphrates.

Dialling. In all dials, the gnomon represents the axis of the earth; hence its angle with the horizon is the latitude of the place, and it lies in the plane of the meridian. There are a great variety of dials, according to whether they are horizontal, oblique, or vertical, and also depending on their aspect with reference to the sun, &c.

Diamicton, according to Pliny, a term used by the Roman builders to designate a particular manner of constructing walls, the exterior of masonry, and the interior of rubble

Diamond, a genus of precious stones of a fine pellucid substance of great hardness, and never debased by any admixture of earthy or other coarse matter. When pure, it is perfectly colourless. It is the most valuable of all gems, and is found only in the East Indies and the Brazils. It is constituted solely of carbon in its densest form.

Diamond, glaziers', the pencil diamond, used in cutting glass, is a small fractured piece of diamond

Diaper ornament, of flowers, applied to a plain surface, either carved or painted: if carved, the flowers are entirely sunk into the work below the general surface; they are usually square, and placed close to each other, and are various in their pattern and design: it was first introduced in the Early English style in some of the principal Gothic structures in England

Diaper, a panel or flat recessed surface covered with carving or other wrought work in low relief; a kind of linen cloth, wrought with figures in the process of weaving

Diastyle, an arrangement of columns in Grecian and Roman architecture, in which the intercolumniation or space between them is equal to three or four diameters of the shaft

Diathyra, the vestibule before the doors of a Greek house, corresponding with the prothyra of the Romans

Diatoni, the angle stones of a wall, wrought on two faces, and which,

stretching beyond the stones above and below them, form a good band or tie to the work

Diatoni, according to Vitruvius, the girders or band-stones formerly employed in constructing walls; corner stones

Diatretum, an enchased or curiously engraved vase or drinking-cup

Diaulon, a race-course, the circuit of which was two stadia, or 1200 feet; whence it was used to signify a measure of two stadia

Dicrotum, a boat with two oars

Die, the cube or dado of a pedestal

Die, or *Dye*, a naked square cube: thus the body of a pedestal, or that part between its base and its cap, is called the die of the pedestal

Dies, two pieces of hardened steel, which, when placed together, form a female screw (or a screw in a nut) which has cutting edges, used for making a screw on a bolt

Die-sinking: in the preparation of coined money and of medals, the most important feature is the engraving of the die which is to form the stamp. The piece of steel is prepared with care, and brought to a soft state when about to be submitted to the hands of the engraver. By the aid of small, fine, hardened steel tools, the engraver cuts away the steel until he has produced, in cavity or intaglio, an exact reverse of the design for the medal or coin.

Dieu et mon droit—'God and my right,'—in heraldry, the motto of the royal arms of England, first assumed by Richard I.

Differential thermometer. This instrument was invented by the same gentleman who contrived the photometer and ætherioscope, and was used by him in his investigations on heat. Its principal use to the meteorologist is to make experiments on the light and heat of the moon, &c., by concentrating its rays by a lens upon the sentient ball. This can only be done when the moon is on the meridian. It is peculiarly adapted for measuring the effect of radiation.

Digester, a boiler invented by Papin for raising water to a higher temperature than the common boiling point, 212°: this is effected by forming a vessel somewhat resembling a kitchen pot; the mouth is formed into a flat ring, so that a cover may be screwed tightly on; this cover is furnished with a safety-valve, loaded to the required pressure

Digit, a finger; a term employed to signify any symbol of number from 0 to 9: thus ten (10) is a number of two digits

Digit, a measure of length, containing three-fourths of an inch

Diglyph, in architecture, an imperfect triglyph, with only two channels instead of three

Dilapidation, decay for want of repair; not unfrequently a point of dispute between a party in possession of a house and another party having an interest therein. Where there is a right to use lands or houses, questions will arise as to the manner in which they ought to be used, and by whom dilapidations, whether caused by accident or decay, ought to be supplied. The rights of parties with respect to immoveable property so closely border on each other, and the line of demarcation between them is so indistinct, that one man, in the fancied exercise of his right, is continually liable to encroach upon or disregard the right of another. No person, however absolute his property in land, can put it to any use he pleases: his right to use is restrained by the rights of his neighbour; he is bound to take care that his manner of using does not interfere with the inoffensive and profitable occupation by his neighbour of his land. (See the second edition, just published, of Mr. Gibbons's elaborate work on the 'Law of Dilapidations and Nuisances.')

END OF PART I.

Dilettante (Italian), an ardent admirer of the fine arts. The Dilettanti Society, consisting of many distinguished noblemen and gentlemen, has done much to rescue the noble monuments of Grecian art from otherwise inevitable ruin

Dilleuing, a Cornish word for a method of washing or finishing the dressing of tin in very fine hair sieves

Diluvial formation, the superficial deposits of gravel, clay, sand, &c., which lie far from their original sites on hills, and in other situations, to which no forces of water now in action could transport them

Dimension, a term used in the same sense as *degree*

Diminution, a term expressing the gradual decrease of thickness in the upper part of a column

Diminution of columns. The shafts of columns are diminished in diameter as they rise, sometimes from the foot itself of the shaft, sometimes from one-quarter, and sometimes from one-third of its height. The diminution at top is seldom less than one-eighth or more than one-sixth of the inferior diameter of the column.

Dioptase, or *emerald copper*, a crystallized silicate of copper, the primary form of which is a rhomboid. Its colour varies from emerald to blackish green: it is translucent and brittle

Dioptra, a geometrical instrument employed in measuring the altitude of distant objects, and for taking the levels of a source of water intended to be conveyed to a distance by means of an aqueduct

Diorama, a mode of scenic exhibition invented by two French artists, Daguerre and Bouton

Dip, in mining, the greatest inclination of a stratum to the horizon

Di Palito is a light yellow ochre, affording tints rather purer in colour than the stone ochre, but less so than Naples yellow. Many pleasing varieties of ochreous colours are produced by burning and compounding with lighter, brighter, and darker colours, but often very injudiciously and adversely to that simple economy of the palette which is favourable to the certainty of operation, effect, and durability.

Diplinthius, according to Vitruvius, two bricks thick

Dipping-needle, in navigation, a magnetic needle, so hung that one end dips, or inclines to the horizon, and the other is proportionally elevated, forming an angle equal to the dipping of the needle at the place where the experiment is made

Dipteral, having a double range of columns all round: a dipteral temple usually had eight in the front row of the end porticoes, and fifteen at the sides, the columns at the angles being included in both

Dipteron, in ancient architecture, a temple surrounded with a double row of columns which form porticoes, called wings or aisles

Dipteros, in Greek architecture, a temple with a double row of columns on each of the four sides

Direct-action engine, an engine having the rotatory motion communicated to a crank placed directly over the cylinder, so as to save height, and lessen the weight of the engine: the term applies more particularly to marine engines

Discharging arch, an arch formed in the substance of a wall, to relieve the part which is below it from the superincumbent weight: it is frequently used over lintels and flat-headed openings

Discord, a term applied to painting when there is a disagreement of the parts or the colouring; when the objects appear foreign to each other, and have an unpleasing and unnatural effect

Disembogue, to pour out at the mouth of a river

Distemper, in painting, the working-up of colours with something else besides mere water or oil. If the colours be prepared with the fire

it is called limning; and with the last, painting in oil

Distemper is a preparation of colours without oil, only mixed with size, whites of eggs, or any such proper glutinous or unctuous substance: with this kind of colour all the ancient pictures, before the year 1410, were painted, as also are the celebrated cartoons of Raphael

Ditriglyph, an interval between two columns, admitting two triglyphs in the entablature; used in the Doric order

Dividiculum, in Rome, a tower on an aqueduct, containing a large reservoir

Diving bell, a machine contrived for safely lowering a man to any reasonable depth under water, so that he may remain there for a considerable time

Division of an Order. The general division of an order being into two parts, namely, the column and entablature, the column is subdivided into three unequal parts, viz. the base, the shaft, and the capital. The entablature consists also of three unequal parts, which are, the architrave, the frieze, and the cornice. Each of these divisions consists of several smaller parts, which by their variety and peculiarity distinguish the orders from each other.

Dock, a place artificially formed for the reception of ships, the entrance of which is generally closed by gates. There are two kinds of docks,—dry docks and wet docks: the former are used for receiving ships for repair, the latter for the purpose of keeping vessels afloat.

Docks are enclosed artificial receptacles for shipping, and are usually formed by excavation of the soil, and constructed walls of masonry, with inlets and gates for admitting the passage of vessels. Docks are usually distinguished as wet docks or basins, and dry or graving docks. The former of these are already described under the head *Basin;* the latter may be described as follows:

Graving docks, in which repairs of vessels are effected, are constructed of various dimensions, according to the class of vessel for which provision is intended. Several splendid works of this kind have, within the last few years, been executed in the English dockyards. One of these,—the Eastern Dock in Her Majesty's Dockyard at Woolwich,—is 282 feet in extreme length, 81 feet in width on the ground level, and 39 feet in the bed. The depth from the ground level to the bed is 27 feet. The inclined sides and curved end of the masonry are formed into a series of steps or altars, by which access is readily obtained to all parts of the dock, and fixing-places obtained for the struts with which the sides of the vessel under repair are maintained in an upright position, when the water is discharged from the dock. The river-wall of this structure was originally constructed of concrete block-facings with rough concrete backing, according to a plan introduced into this country by Mr. Ranger; but these were abandoned, and granite facings substituted, the entire mass of the wall being supported on timber-piling. The whole of the piers, apron, and coffer-dam walls were executed by tide-work, in the following manner: a small space was surrounded by sheet-piling, which was carried up from 6 to 8 feet above the level of low water: into the enclosure thus formed a pipe from two 18-inch pumps, worked by a steam engine, was led, and the pumps set to work as soon as the tide fell below the sheet-piling. The subsequent excavation for the dock reached a bed of chalk, which was found to be sufficiently firm to dispense with the inverted arch of masonry usually constructed beneath the bed of these docks, and the floor was consequently constructed of a horizontal paving of blocks of granite

2 feet in thickness, each stone being joggled to the adjacent stones with dove-tail joggles of Valentia slate bedded in cement. The river water is admitted into the dock through a culvert 5 feet high and 3 feet wide, passing through each pier, and which culverts are worked by sluices of cast iron. The front of the dock is closed with a caisson formed of plate iron, fixed with rivets to ribs of angle iron; the form of the caisson being similar to that of a vessel, namely, with a continuous keel along the bottom and up each end, and a swelling outline tapering towards the end keels, and reduced to a width nearly parallel in the deck-level. This continuous keel, which is of oak, and formed in two pieces, fits into a recess in the masonry at the entrance of the dock, and the admission of water into it is regulated by sluices and pumps.

From the description given of graving docks, it will be understood that their action and efficiency depend upon the command of an adequate depth of water, and a sufficient rise and fall of tide to leave the vessel dry or to float her, as occasion requires. The use of these docks also compels the retention of the vessel during the action of the tide, and thus involves a considerable lapse of time, which sometimes cannot be afforded for trifling repairs or examination of a vessel in active service.

For situations in which no tide exists, a different arrangement becomes necessary, and a construction called a 'slip' is commonly substituted for a graving dock. The slip which has been the most extensively used is that known as 'Morton's slip,' and which was secured by a patent dated March 23, 1819, granted to T. Morton, for a method of dragging ships out of water for repairs, &c. This slip consists of an inclined plane, formed of timber framing laid upon suitable foundations of masonry, or cut in the surface of the rock. Upon this framing longitudinal metal racks are fixed, and a moveable carriage, upon which the vessel is received, (by running the carriage to the lower part of the plane, beneath the water, and securing the vessel upon it,) is fitted with cog-wheels, or other suitable apparatus for working upon these racks. The moving carriage consists of a succession of small strong blocks or carriages, any number of which may be connected together, according to the length of vessel to be hauled up. Each of these blocks or carriages, which are laid in corresponding pairs on each side of the central line of the slip, so as to leave a continuous intermediate space to receive the keel of the vessel, is fitted with rollers, upon which it may be moved transversely; and thus the distance between the two blocks of each pair, or on each side of the centre, may be adjusted according to the sectional form of the ship. These motions are ingeniously effected with the aid of cross ropes or lines which are fixed to the blocks, and by which means the entire action of the apparatus is much facilitated. The combined carriage, when loaded with the vessel, is hauled up the slip by cables attached to a drum apparatus, with suitable gearing fixed in a building at the head or upper end of the slip. The power required is of course in proportion to the weight to be hauled up, and to the rate of inclination of the slip, and is usually supplied by a steam engine.

This principle is susceptible of being extended, so as to provide berths for several vessels with only one hauling-up slip and machinery. For this purpose it has been suggested to construct a series of frames arranged radially round a centre, and capable of motion and of adjustment, with one slip con-

structed in such a direction as to correspond with a produced radius of the same circle. This arrangement, which would be similar to that of the polygonal engine-houses now erected on several lines of railway, offers great facilities for extended operations in the repair of vessels, but of course requires great space for the construction of the radial frames.

In order to provide for cases in which sufficient tidal difference cannot be had for raising vessels of deep draughts on to a dry dock, *floating docks* have been introduced in North America, and found to act satisfactorily. These floating docks are constructed with a buoyant bed, or cradle, capable of supporting a vessel within the dock, with its keel above the surface of the water. This float or cradle is made in a box-like form, composed of strong logs, jointed firmly, and well caulked, so as to make it water-proof. The capacity of the float must be such that when freed from water by pumping, and loaded with the vessel, workmen, &c., it shall sustain this load with safety. The float moves within a recess of masonry, by which its motion is guided and secured. Suitable shores, blocks, struts, &c., are used in making the vessel steady within the float, which is fitted with valves in the lower part. The action of this floating dock is as follows: The cradle or float, being full of water (the valves being open), is sunk so that the vessel may be brought over it, and temporarily secured in position: the valves are then closed, and the pumps set to work to clear the water from the float, which rises in consequence, and brings up the vessel to a dry level. When the ship is again ready for sea, the opening of the valves admits the water, and sinks the float, leaving the vessel free above *it to* pass out of the dock.

The docks and basins of London and Liverpool comprise some of the largest specimens of works of this kind. Those of the latter port were commenced in 1708, and consist of several docks of great extent. The first public docks for merchant shipping in London were the West India Docks, opened in 1805, the great basin of which is 420 yards in length, and 230 yards in width. This is connected with the river by another basin of about three acres in area. The London Docks were commenced soon after the West India Docks, and opened in the same year, viz. 1805. The principal basin of these docks is 420 yards in length, and 276 yards in width. The East India Dock for unloading inwards is 470 yards in length, and 173 yards in width; and that for loading outwards is 260 yards in length, and 140 yards in width. The St. Katherine's Docks occupy an area of 24 acres.

Dodecagon, in geometry, a figure of twelve angles and sides

Dodecahedron, in geometry, one of the regular bodies comprehended under twelve equal sides, each of which is a pentagon

Dodecastyle, a building having twelve columns in front

Dogs, or andirons, creepers, braziers, &c. Long after the general introduction of chimneys, wood was the ordinary fuel for all sorts of apartments. Coals formed no part of the 'liveries,' but wood was commonly included in them. A 'cradle for sea coal' is, however, frequently mentioned as belonging to the chief rooms in superior houses, though the usual way of warming, or rather airing, bed-chambers was with braziers or chafing-dishes. Andirons are a larger and higher sort of irons, made to support the wood, and have usually long necks rising up before, to prevent the wood from falling upon the floor. Creepers are smaller and lower irons, with short necks, or none at all, which are placed between the

andirons, to keep the ends of the wood and the brands from the hearth, that the fire may burn more freely.

Dog-kennel, a lodgement for dogs kept for the purpose of field sports: it is almost as invariable an appendage to the manor-house as it was formerly to the baronial castle. Bishop Percy observes, "that a nobleman in the dark ages, retired within his castle, had neither books, nor newspapers, nor literary correspondence, nor visits, nor cards, to fill up his leisure: his only amusements were field sports; nor did the love for these decline in the Tudor period."

Dog wood, a small underwood, free from silex: small splinters are used by watch-makers for cleaning out the pivot-holes of watches; it is also used by butchers for making skewers

Dolomite, massive magnesian limestone, used by the ancient sculptors in their best works

Dolphin, a technical term applied to the pipe and cover at a source for the supply of water

Dome, a term applied to a covering of the whole or part of a building: the word dome is strictly applied to the external part of the spherical or polygonal roof, and cupola to the internal part

Dome or *cupola*, a roof, the base of which is a circle, an ellipsis, or a polygon, and its vertical section a curve line, concave towards the interior. Hence domes are called circular, elliptical, or polygonal, according to the figure of the base.

The most usual form for a dome is the spherical, in which case its plan is a circle, the section a segment of a circle.

The top of a large dome is often finished with a *lantern*, which is supported by the framing of the dome.

The interior and exterior forms of a dome are not often alike, and in the space between, a staircase to the lantern is generally made. According to the space left between the external and internal domes, the framing must be designed. Sometimes the framing may be trussed with ties across the opening; but often the interior dome rises so high that ties cannot be inserted.

Accordingly, the construction of domes may be divided into two cases: viz. domes with horizontal ties, and those not having such ties.

Dome, in locomotive engines, the conical part of the boiler, forming a steam chamber, and terminating the top of the fire-box part. In a locomotive engine the safety-valves are usually placed on the top of the dome or the body of the boiler

Dome cover, in locomotive engines, the brass or copper cover which encloses the dome, to prevent the radiation of heat

Dome Cathedral of Pisa, the first model of that Tuscan style of architecture, so solid, grave, and imposing, neither Greek nor Gothic, was begun in the eleventh century; and in the thirteenth was founded the majestic church of Santa Maria del Fiori at Florence, of which the dome equals in size that of St. Peter's at Rome, and was its model

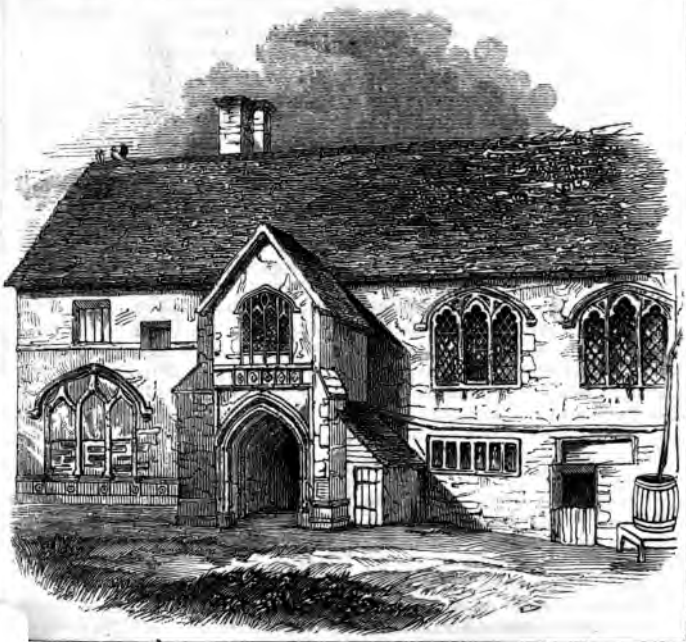
Dome of St. Paul's Cathedral (the) is elliptical, and built of wood; it is confined by strong chains, consisting of iron bars: that of the Pantheon at Rome is nearly circular, and its lower parts are so much thicker than its upper parts as to afford sufficient resistance to their pressure; they are supported by walls of great thickness, and furnished with many projections which answer the purpose of abutments and buttresses

Domes in Asia are probably more ancient than in Italy. At Lankerrood, at Dhay-nain, at Sin-sin, five or six days' journey south of Teheran in Persia, towns are all de-

serted: there are about a hundred large dwelling-houses quite entire, of a very singular construction. Each edifice stands separate, and is constructed of several central arches supporting a pointed dome; while smaller divisions project from the body of the building, also arched, and the whole finished with the greatest neatness, having remains of stucco-painted walls within.

It is probable that the arch and vault and dome were not unknown to the nations in the East, beyond the Indies, in a very remote age; but in Greece and in Asia Minor there are no traces of them before their introduction by the Romans. To the Romans they were familiar at a very early period of their history; a knowledge of which they borrowed perhaps from the Etruscans, or from the supposed extinct people who possessed a city on the site of Rome itself, before the Romans.

Domestic Architecture in England. At the termination of the York and Lancaster wars, the fortified style of architecture was gradually abandoned in England; and as we had no other model of domestic architecture than the gable and the cottage, by the duplication of this simple form, in various positions, was constructed what has been called the Old English Manor-house style. If we take a common two-floored English gable and cottage, add to it one, two, or three cottages side by side, of the same size; and in order to gain rooms out of the roof on the sides of this double or triple cottage, raise gable ends either projecting from the



ground to the top of the roof, or merely raised from the eaves-drop; if we insert broad low windows, divided by simple wooden or stone mullions, in these projecting gable ends, and similar windows at the ends of this double or triple cottage; ornament the inclined sides of the gable ends above the eaves-drop by steps or small pinnacles, or both; then add a parapet, plain or embattled, we have a manor-house in the most florid style. Many such houses came afterwards to be adorned by a centre of architectural decoration, in which Roman, Grecian, and Gothic were strangely mixed. There is, however, a certain degree of antique-like grandeur in such houses, which produces a very striking impression. This step towards a better style took place before the time of Inigo Jones.

"The mansion at South Elmham (represented on the preceding page), when entire, formed a quadrangle, as usual, of which stables and offices made up a part. The domestic and ecclesiastical styles are singularly combined in this building, though the latter seems to predominate; and the occasional discovery of old floor-stones, of a sepulchral character, intimates that the projecting porch led to the chapel of the dwelling, not into the hall; and yet the ceilings of the chambers where the two wings and upper windows are observed, on the right hand of the porch, are flat, divided into small squares by the girders above, and covered with plastered mouldings, in the manner usually seen in dwellings of an early period."

Domestic buildings and *castles*. The towns and ordinary houses of the Normans were entirely built of wood, and, for the most part, are so to this day. Their castles, having but one destination, that of defence, aimed at nothing but strength in their plan or construction. A site was also selected which was already fortified by nature.

The plan of the Norman castles was as nearly the same as the diversity of ground would allow. The principal feature was always the keep, which contained the apartments of the lord of the castle, and was also meant to be the last refuge of the garrison, if the outer works were forced. The keep was usually raised on an artificial mound, or placed on the edge of a precipice. The walls, strengthened in every way that art could devise, were of immense thickness, and composed of grouting poured in between two solid walls of stone. The facing consisted sometimes of irregular courses, and sometimes of small squared stones, after the Roman manner. Ashler was usually introduced at the angles of the building. The windows were few, and little more than chinks, unless very high up, or turned to the court. The door of entrance could only be reached by a staircase.

Under the keep were usually vaults, or dungeons, for the reception of prisoners.

The keep was enclosed in two courts surrounded by walls flanked with towers. The tower at the entrance was called the barbican, and served at once for an outwork and post of observation. The whole fortress was defended by a moat.

The remains of the Norman castles which exist scarcely afford any specimens of early Norman construction, almost all these castles having been besieged, destroyed, and rebuilt, over and over again.

The keep of Falaise is perhaps the only castellated remnant of early Norman times.

The castle of Gizors, which was built by William Rufus, retains nothing of its original construction.

Domus, a private house occupied by a single proprietor and his family

Doors (*Antique*). The Greeks in the temple of Minerva Polias, at

Athens, and also the Romans in the temple of Vesta, or the Sibyl, at Tivoli, made the doors and windows smaller at top than at bottom: the architrave or dressing always constituted an agreeable decoration when in character with the building. Those of the windows in the Grecian temple have a projection, or what is sometimes termed a knee, at their upper angle; while those of the temple of Vesta, whose apertures have the same form, continue without interruption, and are surmounted by a cornice; but the cornice above the door is separated from the architrave by a frieze, while the cornice of the windows joins the architrave. In the temple of Minerva, the architrave of the windows rests only on a plain socle; those of the temple of Vesta rest also on a socle or support, the face of which is sunk.

Doors (*Modern*). There are two doors, designs of Vignola, which offer in their profiles and proportions a happy medium between the antique and modern compositions; and all other designs of this kind are either derived from them, or possess a vague character which renders them unworthy of imitation.

There are breaks in the architrave, as in those of the temple of Minerva Polias; and the termination or lower extremity of these breaks determines the length of the consoles, which gives harmony to the arrangement. These consoles are also placed against a second architrave, beyond which the first projects. The design of the door of the church of St. Lorenzo is more regular.

Doorway (*Anglo-Norman*). The Anglo-Norman builders bestowed much pains and evinced considerable artistic skill in very elaborately ornamenting the portal entrances to churches in their style of architecture, by a profusion of ornamental mouldings and of sculpture. Very many examples are to be met with in great variety in several of the counties of England, particularly in the counties of Norfolk and Suffolk. The example represented in the annexed engraving is a beautiful specimen taken from the church of St. Botolph, at Cove, in the county of Suffolk.

Doorways. In the Gothic, and the architecture of the middle ages, doorways are striking and important features, affording in the character of the mouldings and ornaments the style and period of the edifice.

Doric Order. The Doric order, says Palladio, was invented by the Dorians and named from them, being a Grecian people which dwelt in Asia. If Doric columns are made alone without pilasters, they ought to be seven and a half or eight diameters high. The intercolumns are to be little less than three diameters of the columns; and this manner of spacing the columns is by Vitruvius called Diastylos.

The ancients employed the Doric in temples dedicated to Minerva, to Mars, and to Hercules, whose grave and manly dispositions suited well with the character of this order. Serlio says it is proper for churches dedicated to Jesus Christ, to St. Paul, St. Peter, or any other saints remarkable for their fortitude in exposing their lives and suffering for the Christian faith. Le Clerc recommends the use of it in all kinds of military buildings; as arsenals, gates of fortified places, guard-rooms, and similar structures. It may likewise be employed in the houses of generals or other martial men,—in mausoleums erected to their memory, or in triumphal bridges and arches built to celebrate their victories.

Vitruvius himself makes the Doric column in porticoes higher by half a diameter than in temples; and most modern architects have, on some occasions, followed his example. In private houses, therefore, it may be 16½, 16½, or 16¾ modules high; in interior decorations, even seventeen modules, and sometimes perhaps a trifle more; which increase in the height may be added entirely to the shaft, as in the Tuscan order, without changing either the base or capital. The entablature, too, may remain unaltered in all the aforesaid cases; for it will be sufficiently bold without alteration.

Doric Order. The height of the Doric column, including its capital and base, is sixteen modules; and the height of the entablature, four modules; the latter of which being divided into eight parts, two of them are given to the architrave, three to the frieze, and the remaining three to the cornice.

In most of the antiques, the Doric column is executed without a base. Vitruvius likewise makes it without one; the base, according to that author, having been first employed in the Ionic order, to imitate the sandal or covering of a woman's foot. Scamozzi blames this practice; and most of the moderns have been of his opinion, the greatest part of them having employed the Attic base in this order.

Dorman tree, a large beam lying across a room; a joist, or sleeper

Dormer window, a window pierced through a sloping roof, and placed in a small gable which rises on the side of the roof

Dormitory, a sleeping apartment; a term formerly applied to the sleeping-room of the inmates of monasteries and other religious houses

Dormond, a large beam lying across a room; a joist, or sleeper: same as Dorman

Doron, a hand-breadth, or palm: among the Greeks, their bricks or tiles were termed *tetradoron,* four hands' breadth, or *pentadoron,* five hands broad: the word also implies a gift: hence, probably, the origin of the English word *dowry*

Dosel, hangings round the walls of a hall, or at the east end, and sometimes the sides, of the chancel of a church, made of tapestry or carpet-work; used also in churches, and frequently richly embroidered with silks, and gold and silver

Dosel, ornamental and rich stuff for the back of a chair, a throne, or a screen of ornamental wood-work

Double-acting pump, a pump which lifts and forces water at the same time, by means of a solid piston, and an entrance and exit-valve communicating with each side

Double-beat valve, a valve used in Cornish engines and water-works. It has two beats, or seatings, one above the other: the bottom one is similar to an ordinary circular valve seating; the top one is somewhat less in diameter than the bottom one, and is supported from it by ribs, and forms a cover nearly the size of the inner passage. A shell with two beats to correspond with the seatings shuts the sides: when raised, (which requires but little power, as the fixed cover before mentioned bears nearly all the pressure, its diameter being nearly equal to that of the shell,) the steam or water escapes at the sides both of the top and bottom beat.

Double cylinder engine, a marine engine with two cylinders placed at right angles to the crank-shaft, and at a small distance apart, to give space for the vibration of the rod connecting the crank to the long end of a shaped cross-head, which slides in grooves between the cylinders: the upper ends of the cross-head are connected to the piston-rods. This form of engine is patented by Messrs. Maudsley.

Dove-tail, in carpentry, a method of joining two boards together by letting one piece into another in the form of the tail of a dove, when that which is inserted has the appearance of a wedge reversed

Dove-tailing, a method of fastening together two pieces of metal or wood, by projecting bits cut in the form of dove-tails in one piece, to fit into corresponding hollows in the other

Dowel. A round dowel or coak is *the piece of* timber to which the felloes of a carriage-wheel are united

Dowsing cheeks, in ship-building, pieces fayed across the apron, and lapped on the knightheads or inside stuff above the upper deck

Draft-engine, an engine used for pumping

Drag-bar, a strong iron rod with eye-holes at each end, connecting a locomotive engine and tender by means of the drag-bolt and spring

Drag-bolt, the strong bolt coupling the drag-bar of a locomotive engine and tender together, and removeable at pleasure

Drag-hook and chain, the strong chain and hook attached to the front of the engine buffer-bar, to connect it on to any other locomotive engine or tender: also attached to the drag-bars of goods waggons

Drag-link, a link for connecting the cranks of two shafts: it is used in marine engines for connecting the crank on the main-shaft to that on the inner paddle-shaft

Drag-spring, a strong spring placed near the back of the tender. It is attached by the ends to the drag-bar which connects the engine and tender, and by the centre to the drag-bar which connects the train to the tender.

Dragon's blood (colour), a resinous substance brought from the East Indies. It is of a warm semi-transparent, rather dull-red colour, which is deepened by impure air, and darkened by light. There are two or three sorts, but that in drops is the best. White lead soon destroys it, and it dries with extreme difficulty in oil. It is sometimes used to colour varnishes and lacquers, being soluble in oils and alcohol; but notwithstanding it has been recommended as a pigment, it does not merit the attention of the artist.

Drainage of marshes and fen lands. The steam engine is used to raise the water above the level of those lands which lie too low to be drained

by natural outfall, and also in situations where the fall is not sufficient to carry off the superfluous water in time to prevent damage to the crops.

Mr. Glynn has applied steam power to the drainage of land in fifteen districts, all in England, chiefly in Cambridgeshire, Lincolnshire, and Norfolk. The quantity of land so drained amounts to more than 125,000 acres, the engines employed being seventeen in number, and their aggregate power 870 horses: the size of the engines varies from 20 to 80 horses. Mr. Glynn was also engaged in draining by steam power the Hammerbrook district, close by the city of Hamburgh; and in another level near to Rotterdam, an engine and machinery with the requisite buildings have been erected from his plans by the Chevalier Conrad, and the works successfully carried into effect.

In British Guiana the steam engine has been made to answer the double purpose of drainage and irrigation. Some of the sugar plantations of Demerara are drained of the superfluous water during the rainy reason, and watered during the dry season.

In many of the swampy levels of Lincolnshire and Cambridgeshire, much had been done to carry off the water by natural means, and many large cuts had been made and embankments formed, especially in the Bedford Level, which alone contains about 300,000 acres of fenland: the Great Level of the fens contains about 680,000, formerly of little value, but now rich in corn and cattle.

The general plan is to carry away the water coming off the higher grounds, and prevent it, as much as possible, from running down into the marsh by means of the catchwater drains, leaving the rain alone which falls upon the district to be dealt with by mechanical power.

As the quantity of rain falling on the Great Level of the fens seldom exceeds 26 inches in the year, and about two-thirds of this quantity is carried off by evaporation and absorption, or the growth of plants, it is only in extreme cases that 2 inches in depth require to be thrown off by the engines in any one month, which amounts to $1\frac{1}{2}$ cubic foot of water upon every square yard of land, or 7260 feet to the acre.

The standard and accepted measure of a horse's power is 33,000 lbs. raised 1 foot high in a minute, or 3300 lbs. raised 10 feet high in the same time; and as a cubic foot of water weighs $62\frac{1}{2}$ lbs., and a gallon of water 10 lbs., so one horse's power will raise and discharge, at a height of 10 feet, 330 gallons, or $52\frac{8}{10}$ cubic feet of water in a minute. Consequently this assumed excess of 7260 cubic feet of water fallen upon an acre of land will be raised and discharged at an elevation of 10 feet in about two hours and twenty minutes. If the quantity of land be 1000 acres of fen or marsh, with the upland waters all banked out, the excess of rain, according to the foregoing estimate, will amount to 726,000 cubic feet. A steam engine of 10-horse power will throw off this water in 232 hours, or in less than twenty days, working twelve hours a day. This calculation has been found fully supported in practice.

Although the rain due to any given month may fall in a few days, yet in such case much of it will be absorbed by the ground; and the drains must be made of sufficient capacity to receive and contain the rain as it falls; besides, in case of necessity, the engine may be made to work twenty hours a day instead of twelve, until the danger be past.

The main drains have generally been cut $7\frac{1}{2}$ feet deep, and of width sufficient to give them the required capacity to contain the excess of rain, and to bring the water freely

down to the engine. In some instances, where the districts are extensive and their length great, it has been found necessary to make them somewhat deeper.

In all cases where it has been requisite to use steam power, Mr. Glynn has applied scoop-wheels to raise the water. These scoop-wheels somewhat resemble the undershot wheel of a water-mill, but instead of being turned by the impulse of the water, they are used to lift it, and are kept in motion by the steam engine.

The floats or ladle-boards of the wheels are made of wood, and fitted to work in a trough or track of masonry; they are generally made 5 feet in length, that is to say, they are immersed 5 feet deep in the water, and their width or horizontal dimension varies from 20 inches to 5 feet, according to the power of the engines employed, and the head of water to be overcome. The wheel-track at the lower end communicates with the main drain, and at the higher end with the river; the water in the river being kept out by a pair of pointing doors, like the lock-gates of a canal, which close when the engine ceases to work. The wheels themselves are made of cast iron, formed in parts for convenience of transport. The float-boards are connected with the cast-iron part of the wheel by means of oak-starts, which are stepped into sockets cast in the circumference of the wheel to receive them.

There are cast-iron toothed segments fitted to the wheel, into which works a pinion fixed upon the crank-shaft of the steam engine. When the head of water in the river or delivering drain does not vary much, it is sufficient to have one speed for the wheel; but where the tide rises in the river, it is desirable to have two speeds or powers of wheel-work, the one to be used at low water, the other more powerful combination to act against the rising tide. But in most cases it is not requisite to raise the water more than 3 or 4 feet higher than the surface of the land intended to be drained; and even this is only necessary when the rivers are full between their banks, from a continuance of wet weather, or from upland floods.

In some instances, the height of the water in the rivers being affected by the tide, the drainage by natural outfall can take place only during the ebb; and here, in case of long-continuing rains, the natural drainage requires the assistance of mechanical power.

It has been stated that the main drains have generally been made 7½ feet deep, or more in larger districts, so that the water may never rise higher than within 18 inches or 2 feet of the surface of the ground, and the ladles or float-boards dip 5 feet below the water, leaving a foot in depth below the dip of the wheel, that the water may run freely to it, and to allow for the casual obstruction of weeds in the main drain, which, if it be sufficiently capacious and well formed, will bring down the water to the engine with a descent of 3 inches in a mile.

Suppose then that the wheel dips 5 feet below the surface of the water in the main drain, and that the water in the river into which this water must be raised and discharged has its level 5 feet above that in the drain, the wheel in such case will be said to have 10 feet head and dip, and ought to be made 28 or 30 feet in diameter.

Mr. Glynn has found it practicable to throw out the water against a head of 10 feet with a dip of 5 feet, that is to say, 15 feet of head and dip, with a wheel of 35 feet in diameter; but in another engine, more recently erected, he has made the wheel 40 feet in diameter. The engine that drives this wheel is of 80-horse power, and is situated on

the Ten-mile Bank, near Littlepool, in the Isle of Ely. The largest quantity of water delivered by one engine is from Deeping Fen, near Spalding: this fen contains 25,000 acres, and is drained by two engines, one of 80 and one of 60 horse power.

The 80-horse engine has a wheel of 28 feet in diameter, with float-boards or ladles measuring 5½ feet by 5 feet, and moving with a mean velocity of 6 feet per second; so that the section of the stream is 27½ feet, and the quantity discharged per second 165 cubic feet; equal to more than 4½ tons of water in a second, or about 16,200 tons of water in an hour.

It was in 1825 that these two engines were erected, and at that time the district was kept in a half-cultivated state by the help of forty-four wind-mills, the land at times being wholly under water. It now grows excellent wheat, producing from four to six quarters to the acre. In many districts, land has been purchased at from £10 to £20 an acre, by persons who foresaw the consequences of these improvements, and which they could now sell at from £50 to £70 an acre.

This increase in value has arisen, not only from the land being cleared from the injurious effects of the water upon it, but from the improved system of cultivation it has enabled the farmers to adopt.

The fen-lands in Cambridgeshire and great part of the neighbouring counties are formed of a rich black earth, consisting of decomposed vegetable matter, generally from 6 feet to 10 feet thick, although in some places much thicker, resting upon a bed of blue galt, containing clay, lime, and sand.

Draining, as applied to lands, towns, and buildings, is the art of drawing or conveying away refuse liquid and other matters, the accumulation of which would be detrimental to animal and vegetable existence.

In that department which relates to lands, draining comprehends also the methods of *irrigating* or supplying water for agricultural purposes, for which the natural supply is inadequate. Referring to towns and buildings, this art includes also, for the purpose of thorough cleansing, the artificial supply of water.

According to this comprehensive definition, which will be found to have greater practical convenience than any more limited one, Draining comprises observations of the relative levels of districts and of their geological structure; of the several sources of water, and the amount of their products; and the construction and arrangement of all the artificial appliances required for the supply, conduct, and disposal of water, and for conveying and discharging refuse matters generally.

The sources of water are rains and the ocean. The former, passing into the earth, descend along the lower surfaces, and form streams and rivers; or penetrate into some permeable media, and accumulating in subterranean depositories, form springs.

An examination of the superficial and structural features of the soil enables us to estimate the quantity of water present in a district, and to determine the means that will be available for supplying the deficiency or discharging the excess.

The same observations afford general information required in order to arrange the artificial channels, drains, sewers, &c., by which the supply and refuse matters are to be conducted and disposed of.

Soils are retentive of water in proportion to their density and compactness. Thus, on clay-lands an excess of water is commonly found, while, from the porous textures of gravel and loose sand, water passes rapidly away, and they are thus kept in a dry condition.

The *size* of the channels or *drains*, by which the water is conducted away, will be adapted to the superficial extent to be drained, and the quantity of water due to the district, as computed from its relative position and structure. The *construction* of the drains will depend upon the materials of the soil, and the proximity of those suitable for the purpose. Generally, *covered* drains are far preferable to open ones; and those formed with a duct of *earthen piping* are more durable and economical than any others. The *implements* used are rods and levels, for measuring distances and ascertaining inclinations of surface;—tools for boring the soil, to examine substrata, and detect springs, consisting of augers, chisels, punches, &c.;—spades, shovels, and picks of various forms and dimensions; and hoes, scoops, &c. for clearing out and finishing the form of drains.

For the draining of towns and buildings, including the artificial supply of water, the best available sources—such as rivers and springs—are resorted to, and the advantageous use of these will require a careful consideration of the *qualities* of the water obtained, and its suitability for domestic and manufacturing purposes. Arrangements are required for making the water furnished by rains available to the full extent, and rendering it and all other waters fit for use by subsidence, filtration, and purification.

For discharging the refuse matters from houses and other buildings, and from streets and public thoroughfares, drains and sewers of various forms and materials are to be selected, made of *ample dimensions* and permanent construction, with such vertical inclination, and so arranged, that their contents shall always have a tendency to run off, and never suffer interference from the discharge of other channels.

As a final point to be observed in any system of town-drainage, that of the ultimate disposal of the refuse matters is one of the highest importance in both a sanatory and an economical point of view. Collected in proper reservoirs, and judiciously treated, these matters may be distributed in fertilizing streams over the fields and the gardens of the suburbs, and will thus realize immense value in improved and augmented crops: allowed to accumulate in cesspools beneath human dwellings, they engender malignant and fatal disease, and if finally discharged into a river, by way of getting rid of them, they pollute waters otherwise wholesome, and, in dry seasons, send forth from the banks the most unhealthy gases.

Draught, in ship draughting, the drawing or design by which the ship is to be built, which is generally by a scale of one-fourth of an inch to a foot

Draute-chamber, a retiring or withdrawing room

Draw-bore, the pinning a mortise and tenon, by piercing the hole through the tenon nearer to the shoulder than the holes through the cheeks from the abutment in which the shoulder is to come in contact

Draw-bore pins, pieces of steel in the shape of the frustrum of a cone, somewhat tapered, and inserted in handles with the greatest diameter next to the handle, for driving through the draw-bores of a mortise and tenon, in order to bring the shoulder of the rail close home to the abutment on the edge of the style: when this is effected, the draw-bore pins, when more than one are used, are taken out singly, and the holes filled up with wooden pegs

Drawbridge. All drawbridges are composed of two distinct parts, viz. the platform, which revolves on a horizontal axis, acting as a barrier or gate when in a vertical position,

and becoming a bridge when in a horizontal position; and the contrivance necessary to balance the platform in every position. The equilibrium should be such that friction is the only force to be overcome in raising or lowering the platform.

The chief difference between drawbridges lies in the arrangement of this latter contrivance; for the platforms only differ in small details of construction, which have very little influence on the qualities which are essential to the arrangement of the balancing apparatus. These qualities remain the same, whether the drawbridges are used for closing communications in fortified works, or merely for forming passages across navigable canals. They are principally as follows:

1st. The whole system should possess sufficient strength to be perfectly free from danger in all positions and at all times, and should therefore be constructed of solid and lasting materials.

2nd. A small number of men should be able to raise or lower the bridge in a short space of time. This quality requires all the parts to be in equilibrium when friction is not considered.

3rd. The machinery for raising and lowering the bridge should not obstruct the communications either in front or in rear of the buttresses of the gateway where it is placed; and also the space formed by raising the bridge should be as wide as possible, for this space constitutes the chief use of the bridge.

4th. The counterpoise and the machinery attached to it should be raised as little as possible above the platform when vertical, in order that it may not be much exposed to an enemy's fire, and that it may be easily covered by the advanced works; besides that, by raising it, the expense of constructing and the inconvenience of working the machinery are increased, and the strength of the gateway or postern is sometimes diminished.

5th. The counterpoise and its machinery should not be much below the level of the ground, and particularly very little below the level of the surface of the water in wet ditches. At all events, the descending parts should be enclosed in narrow shafts of masonry secure from damp. In order not to weaken the postern walls, they should be at least 3 feet in rear of them.

Drawing is the art of representing objects on a flat surface by lines describing their forms and contours alone, independently of colour or even shadow, although the latter is closely allied with drawing, both in practice and theory

Drawings in pencil are sometimes required to be fixed: this can be done by using water-starch made to the consistency of that employed by laundresses: it should be applied with a broad camel's hair brush, as in varnishing. Isinglas size, and rice-water, are sometimes used, but are not so good as the first-named substance.

Dredge's Suspension Bridge consists in making the chains of sufficient magnitude and strength at the points of suspension to support with safety the greatest permanent and contingent load to which, under the circumstances of locality, they are ever likely to be exposed; and from thence, to taper or diminish them gradually to the middle of the bridge, where the strain becomes essentially evanescent. The gradual diminution of the chains, however, is not the only peculiarity which characterizes this mode of construction, and marks its utility. The suspending-rods or bars that support the platform, or roadway, instead of being hung vertically or at right angles to the plane of the horizon, are inclined to it in angles which vary in magnitude from the abutments to the middle of the bridge, where the obliquity, as well

as the stress upon the chains, attains its minimum value.

Dredging machines, mechanical contrivances placed in the hull of a vessel, and floated in situations for the dredging and clearing away of deposited matter from the beds of rivers, canals, harbours, basins, &c. Some machines for these purposes are to be compared to harrows or shovels, which loosen the deposit preparatory to its removal either by the action of the tide or stream; but for the more general purposes of dredging, vast improvements have been effected. The machinery of the best construction is described in Weale's 'Quarterly Papers on Engineering.'

Dressings, the mouldings and sculptured decorations of all kinds which are used on the walls and ceilings of a building for the purpose of ornament

Drift, a piece of hardened steel, notched at the sides and made slightly tapering: it is used for enlarging a hole in a piece of metal to a particular size by being driven through it

Drift, the horizontal force which an arch exerts with a tendency to overset the piers from which it springs

Drifts, in the sheer draught, are where the rails are cut off and ended with a scroll. Pieces fitted to form the drifts are called drift-pieces.

Driftway, in mining, is a passage cut under the earth from shaft to shaft

Drill, a tool for cutting a circular hole in a piece of metal

Drilling machine, a machine for cutting circular holes in metal by means of a revolving drill

Drilling, the art of boring small holes. Drilling may be effected in a lathe. The drill is screwed upon the spindle, so that its point shall turn exactly opposite that of the screw in the shifting head. Various ingenious improvements have recently been made.

Drip, the projecting edge of a moulding channeled beneath, so that the rain will drip from it: the corona of the Italian architects

Dripstone, called also the 'label,' 'weather moulding,' and 'water table,' a projecting tablet or moulding over the heads of doorways, windows, archways, niches, &c.

Driver, the foremost spur in the bulge-ways, the heel of which is fayed to the foreside of the foremost poppet, and the sides placed to look fore and aft in a ship

Driver, the bent piece of iron fixed in the centre chuck, and projecting over it to meet the carrier, and drive it forward

Driving shaft, any shaft which gives motion to another shaft

Driving springs, the springs fixed upon the boxes of the driving axle of a locomotive engine, to support the weight and to deaden the shocks caused by irregularities in the rails

Driving wheels, the large wheels of a locomotive engine, which are fixed upon the crank-axle, or main shaft of the engine

Drum, in architecture, the bell-formed part of the Corinthian and Composite capitals

Drum, a hollow cylinder fixed on a shaft, for driving another shaft by a band

Drummond light, a peculiar light invented by the late Capt. Drummond, called a heliostat, which reflected the sun's rays in sufficient abundance to render the station which was to be observed visible. This invention obviated the difficulty of distinguishing the stations chosen for the angular points of the triangles in a geodesical survey: where those stations are many miles asunder, it is necessary to have recourse to illuminations even in day-time.

Druxey, timber in a state of decay, with white spongy veins

Dryness is a term by which artists express the common defect of the

early painters in oil, who had but little knowledge of the flowing contours which so elegantly show the delicate forms of the limbs and the insertion of the muscles; the flesh in their colouring appearing hard and stiff, instead of expressing a pleasing softness. The draperies of those early painters, and particularly of the Germans, concealed the limbs of the figures, without truth or elegance of choice; and even in their best masters, the draperies very frequently either demeaned or encumbered the figures.

Dry-rot, a disease affecting timber, and particularly the oak employed for naval purposes. Many contrivances are employed as remedies which have recently been patented, and have been successfully applied.

Dub, to work with the adze

Ductilimeter, an instrument for comparing the ductility of lead, tin, &c.

Ductility is that property of bodies which admits of their being drawn out in length, while their diameter is diminished, without any actual fracture. Gold, silver, platinum, iron, copper, zinc, tin, lead, nickel, are ductile in the order here given: wire-drawing depends on ductility.

Ductility, the property possessed by certain bodies of yielding to percussion, and receiving a change of form without breaking

Dums (in Cornish), frames of wood like the jambs of a door or the frame of a window; set in loose ground in adits and places that are weak and liable to fall in or tumble down

Dungeon, a place of incarceration, formerly the principal tower or keep of a castle: it was always the strongest and least accessible part of a building

Durbar (Persian), a court or building where the sovereign or viceroy gives audience

Dutch Pink, *English* and *Italian Pinks*, are bright yellow colours used in distemper and for paper-staining, and other ordinary purposes. The pigment called 'stil,' or 'stil de grain,' is a similar preparation, and a very fugitive yellow, the darker kind of which is called Brown Pink.

Dutch School of Painting.—This school of art cannot be said to possess the perfections that are to be observed in the Flemish school; their subjects are derived from the tavern, the smith's shop, and from vulgar amusements of the rudest peasants. The expressions are sufficiently marked; but it is the expression of passions which debase, instead of ennobling human nature. It must be acknowledged, at the same time, that the Dutch painters have succeeded in several branches of the art. If they have chosen low subjects of imitation, they have represented them with great exactness; and truth must always please. If they have not succeeded in most difficult parts of the chiaro-oscuro, they at least excel in the most striking, such as in light confined in a narrow space, night illuminated by the moon, or by torches, and the light of a smith's forge. The Dutch understand the gradations of colours. They have no rivals in landscape painting, considered as the faithful representation of a particular scene; but they are far from equalling Titian, Poussin, Claude Lorraine, &c., who have carried to the greatest perfection the ideal landscape; and whose pictures, instead of being the topographical representation of certain places, are the combined result of every thing beautiful in imagination or in nature.

Dyeing is the art of staining textile substances with permanent colours

Dyke, in coal mining, the banks of basalt or whin, by which the coal strata are frequently divided

Dynamics, the science of moving powers, or of the action of forces on solid bodies when the result of that action is motion.

GENERAL DEFINITIONS.

1. The *mass* of a body is the quantity of matter of which it is

composed, and is proportional to its weight, or to the *force* which must be applied to the body to prevent its gravitating to the earth, and which, being greater or less as the mass is greater or less, we regard as a measure of the mass itself.

2. *Density* is a word by which we indicate the comparative closeness or otherwise of the particles of bodies, and is synonymous with the term *specific gravity*. Those bodies which have the greatest number of particles, or the greatest quantity of matter, in a given magnitude, we call *most dense;* those which have the least quantity of matter, *least dense.* Thus *lead* is more dense than freestone; *freestone* more dense than oak; and *oak* more dense than cork.

3. The *velocity* with which a body in motion moves, is measured by the space over which it passes in any given time; the unit usually assumed being one *second.*

4. If the body passes over an equal space in each successive unit of time, the body is said to move *uniformly*, or to have a *uniform velocity*, and the measure of such velocity is the space actually passed over by the body in each second.

5. If, however, the body passes over a *greater* space in each successive second than it did in the preceding, then it is said to move with an *accelerated velocity:* when the differences between the spaces moved over in any two successive seconds is the same, at whatever period of the body's motion they be taken, or in other words, when the successive spaces form an arithmetical progression, the body is said to move with a *uniformly accelerated* velocity; but when the spaces passed over in successive seconds increase according to any other law, the body is then said to have its velocity *variably accelerated.*

6. If, on the other hand, the body passes over a *smaller* space in each successive second than it did in the preceding, then it is said to move with a *retarded* velocity; which, if the successive spaces form a decreasing arithmetical series, is said to be *uniformly retarded;* if otherwise, it is said to be *variably retarded.*

7. The *velocity* of a body whose motion is variable is expressed at any moment by the space which it *would pass over in a second*, if its velocity at the moment spoken of were to continue *uniform for that period.*

8. *Mechanical effect* is measured by the product of the *mass* or *weight* of the body into the space over which it has been moved; no regard being had to the time occupied. The unit of mechanical effect is a weight of one pound raised through a space of one foot.

9. The *momentum* of a body in motion means the mechanical effect which such a body will produce in a *moment* (or second) of time, and varies as the weight of the body multiplied by its *velocity.*

10. The *vis viva* of a body in motion is the whole mechanical effect which it will produce in *being brought to a state of rest*, no regard being had to the time in which the effect is produced, and it varies as the weight of the body multiplied by the *square of its velocity.*

Dynamometer, an instrument which measures any thing to which the name of power has been given, whether that of an animal or otherwise

Dysodile, a papyraceous brown coal

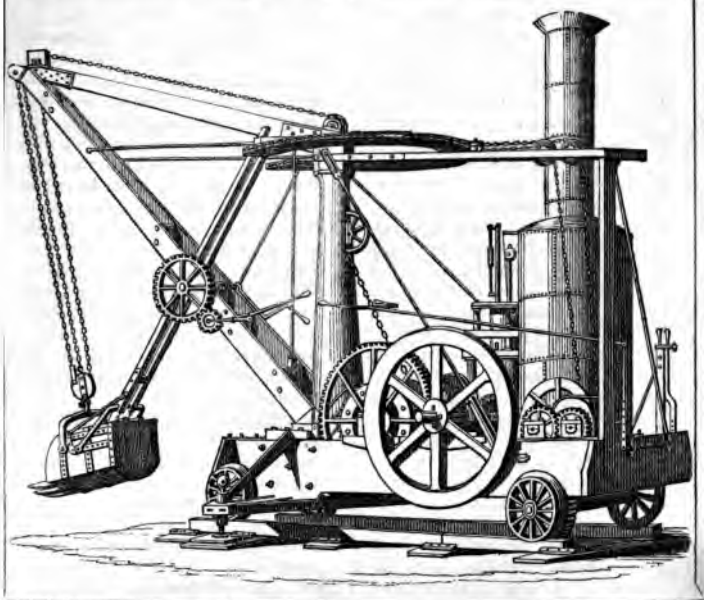
EAR EAR

Early English Architecture, the first of the pointed or Gothic styles of *architecture used in* England. It immediately succeeded the Norman towards the end of the 12th century, and gradually merged into

the Decorated at the end of the 13th. The mouldings consist of alternate rounds and deeply cut hollows, with small fillets, producing a strong effect of light and shadow. The arches are usually equilateral or lanced-shaped, though drop-arches are frequently met with, and sometimes pointed segmented arches: trefoil and cinquefoil arches are also often used in small openings and panelings. The doorways of this style, in large buildings, are often divided into two by a single shaft or small pin, with a quatre-foil or other ornament. The windows are almost universally of long and narrow proportions, and are used singly, or in combinations of two, three, five, and seven: when thus combined, the space between them sometimes but little exceeds the width of the mullions of the later styles. Groined ceilings are very common in this style. The pillows usually consist of small shafts arranged round a larger circular pier, but others of a different kind are sometimes found. The capitals consist of plain mouldings, or are enriched with foliage and sculpture characteristic of the style.

Earth-work. The patented excavator, originally an American invention, is capable of cutting and levelling earth-work for the making of railways and for other works at a cost considerably below manual labour, and which has the additional advantage of saving much time: it forms an important consideration in railway making.

By the attendance of the engineman and assistant, together with the labour of six men for carting away the removed earth-work, this machine, it is said, can be made to excavate 1500 cubic yards in twelve hours, at a cost of fuel of



12*s*. per diem. The cost of the machine is £1500. Earth-work in England has generally been taken at 10*d*. to 1*s*. per yard.

This apparatus is a strong rectangular frame of wood, or other material, mounted upon wheels, supported, together with the machine, on a temporary railroad: at one end of this frame is a strong crane, consisting of a vertical shaft or pillar, with the jib supported by diagonal stays, or arms: to the end of the chain tackle is suspended a scoop, shovel, or scraper, made of strong boiler-plate iron, and consisting of two sides, end, and bottom, the edge of which latter is provided with four or more projecting points or cutters; and between these, and at their roots, is a steel edge, well tempered, so as to resist stone or other hard subtance with which it may come in contact: the chain tackle is attached to the sides of the shovel, and passes over a pulley at the end of the jib, and over another pulley fixed on the top of the pillar or support of the crane, and from thence to the barrel, upon which it is made to coil: the periphery of the last-mentioned pulley is formed with indentations to receive the links of the chain, for the purpose of giving motion to the pulley, which has on its axis a bevel-wheel, taking into and driving a similar wheel, upon the end of an inclined shaft, which shaft actuates certain machinery fixed to and supported by the diagonal arms of the crane. This machinery consists of a barrel, with other appurtenances, round which is passed a chain, with its ends attached to the opposite ends of a beam or arm, which is also fixed to the shovel or scraper. The crane is capable of being moved round, so as to turn the scoop, when elevated, either to the right or left, in a horizontal direction: for this *purpose a* 'horse-shoe pulley,' having a groove in its periphery, is affixed to the upper part of the crane: a chain, attached at each end to a transverse bar, passes round this pulley, and over certain horizontal and vertical guide pulleys, to a barrel, in such a manner that, by reversing the motion of the barrel, the jib of the crane can be turned either to the right or left. A steam engine is erected at one end of the rectangular frame, or platform, for the purpose of giving motion to the various parts of the apparatus. When commencing operation, the shovel, or scraper, is suspended by the chain tackle in a nearly vertical position, with the steel points towards the ground: by releasing the clicks, or catches, of the chain barrel, and applying the brake, the shovel will be lowered, and force itself, by its own weight, into the ground; then by communicating motion to the chain barrel, the tackle will be raised, and, by means of the indented grooved pulley, motion will be given to the shaft, which actuates the machinery on the diagonal arms, which in its turn will force forward the shovel into the ground. At the same time that this motion is going forward, the shovel, or scraper, is being raised or lifted up by the tackle, by which means the shovel has a double motion,—a thrusting forward motion and a lifting motion. When the shovel has become filled, and attained its proper altitude, these motions stop; and the shovel being prevented from returning by the clicks, or catches, the other barrel is thrown into gear by means of a coupling or clutch-box, and the crane turned round so as to bring the shovel over the cart, or other place of deposit; and by certain arrangements it is turned up so as to empty itself; in which position it is again ready for another operation.

Easel, for painters, the frame on

which the canvas is laid, stretched for painting

East Indian Black wood grows to an immense size, and is much used for making furniture

Easter, a moveable feast held in commemoration of the Resurrection. Being the most important and most ancient in observance, it governs the other moveable feasts throughout the year.

Eaves, the lower edge of a sloping roof which overhangs the face of a wall, for the purpose of throwing off the water

Ebony wood is of several colours, as yellow, red, green, and black. The latter is always preferred, and is much used. It is imported principally from the East, and is used for cabinet, mosaic, and turnery work, for flutes, handles of doors, knives, surgeons' instruments, piano-forte keys, &c.

Eborarius, a term applied by the Romans to a kind of ivory-work

Eccentric, or *Excentric*, a circular disc revolving within a strap or ring, and having its axis of revolution on one side of the centre. It is used as a substitute for a crank for giving a reciprocating motion to the slide-valve or to the feed-pump of a steam engine.

Eccentrics are circular sheaves with a hole for the driving-wheel axle, about 2 inches out of the centre of the sheave of a locomotive engine, which thus makes it project some 4 inches more from the centre of the driving axle on one side than on the other. It is this eccentricity of motion which works the slide-valve gear and pumps in a very satisfactory manner. Eccentrics are fitted in two parts, and secured to the axle by a hoop and set-bolts.

Eccentric hoops, hoops fitted round the projecting part of the eccentric sheaves of a locomotive engine, to strengthen them

Eccentric rod and *strap*, the rod, the strap end of which encircles the eccentric sheave, and the other end connects it with the quadrant, or rocking-shaft, according to the class of a locomotive engine. In some engines the end is forked to go on the stud of the rocking-shaft, and opens out something like the letter V; or when only one rod is used for both back and forward movements, it resembles the letter X. In other engines it is attached to the quadrants by a bolt, one rod for forward gear, and another rod for backward gear.

Eccentric rod, the rod connecting the eccentric strap to the lever which moves the slide-valve

Eccentric strap, a brass ring formed by two pieces bolted together, and fixed to the eccentric rod: the ring fits a grooved part in the circumference of the eccentric

Echinus, the egg and anchor, or egg and tongue ornament found carved on the ovolo, in classical architecture

Echinus, a member of the Doric capital; so called from its resemblance to the echinus, or large vase, in which drinking-cups were washed

Ecphora, the projection of any member or moulding before the face of the member or moulding next below it

Eduction pipe, the pipe from the exhaust passage of the cylinder to the condenser

Effect is the art of giving to a drawing a striking appearance, or solemnity, awe, sadness, mirth or tranquillity, by a judicious combination of objects, and by strong light and shadow. It is a faithful representation of the appearance of nature, best seen under certain circumstances and at certain times, such as morning effect, evening effect, twilight effect, and stormy effect, torch-light and candle-light effects, &c.

Effects of buildings. "The site adapted for buildings, and the accompaniments of terraces, gardens, and other decorations to set off their

architectural designs, are subjects for consideration in which we are influenced by the desire to raise and extend the theory and practice to what we consider belongs to the art. It was in Italy, when the fine arts were in perfection, that the laying out great villas was practised by artists who often combined the practice of painting and architecture; and until it be adopted in England, the designs of the architect never will have justice done to them in the execution. Our parks may be beautiful, our mansions faultless in design; but nothing is more rare than to see the two properly connected. Let the architect by study and observation qualify himself to include in his art the decorations around the immediate site of the intended building, together with its interior adornment, furniture, and upholstery, and the growing taste among the gentry of England will second such laudable efforts."

Egyptian Architecture had its origin 2222 years before Christ, and advanced and flourished under different dynasties. The first includes the two great dynasties of Theban princes, who governed Egypt during her "most high and palmy state," when Thebes sent forth her armies to distant conquest. In the second period is comprised the erection of the Pyramids. The third includes the reigns of the Ptolemies and earlier Cæsars, under whom Egyptian architecture flourished in a second youth, and almost attained its original splendour. Egyptian architecture, so massive and so sombre, with its vast aisled halls without windows, its close files of gigantic columns, and its colossal statues, owes many characteristic forms and effects to earlier cavern temples in Ethiopia. One of the most striking peculiarities of the style is the pyramidal character of the ascending lines: it is observed in the outline of the portal and the gigantic pylon, in walls, doorways, pedestals, and screens: it pervades the whole system, and must have been occasioned by circumstances connected with its origin. The representations given in ancient paintings show a remarkable love of uniformity of arrangement of their domestic houses and gardens. In an ordinary house a number of chambers were ranged round a rectangular court, as at Pompeii. The larger mansions sometimes consisted of an assemblage of such courts, the whole occupying a square or oblong plot. Sometimes a central group of buildings was surrounded by a narrow court. A spacious area often extended from front to rear, with a chief and side entrances at either end: the exterior had nothing of the ponderous character of temple structures, which would have been ill-suited to the wants and festivities of social life. Houses two and three stories high were common; but large mansions appear to have been low and extensive rather than lofty. The terraced top was covered by an awning or roof, supported on light graceful columns.

Eidograph, an instrument contrived for the purpose of copying drawings

Ekeing, in ship-building, a piece fitted to make good a deficiency in length on the lower part of the supporter under the cat-head, &c.; likewise the piece of carved work under the lower end of the quarter-piece at the aft part of the quarter-gallery

Elastic, springy, having the power of returning to the form from which it was distorted

Elastic force of steam. The French reckon an atmosphere to be equal to a column of mercury ·76 of a metre in height, which is only 29·92 inches, and the boiling point of their thermometer is adapted thereto; whereas, since about the

commencement of the present century, the English have reckoned it to be 30 inches. This circumstance accounts in some degree for their scale of temperatures differing from Mr. Southern's.

The French account of the occasion of making their experiments on the temperatures corresponding to different elasticities of steam, in 1829, contains the following passage: "Science did not then possess this knowledge, and engineers appointed to superintend the construction of steam engines had no other guidance than some discordant measures upon the temperatures which correspond to the elasticities between one and eight atmospheres: for higher pressures there was no result of direct experiments, nor any theory which could supply the deficiency."

Elder wood. The branches of the elder contain a very light kind of pith, which is used, when dried, for electrical purposes; the wood is also frequently used for carpenters' rules, weavers' shuttles, &c.

Electrical state of the atmosphere. The electrical condition of the air in serene and tempestuous weather has been too much overlooked by meteorologists. The atmosphere is generally found to be in an electrical state. The apparatus for these observations is simply a metallic rod, insulated at its lower extremity, elevated at some height above the ground, and communicating with an electroscope. When the amenity of the weather will permit, a kite should be raised, in the string of which a metallic wire should be interwoven: this will collect the electricity of the higher regions of the air. The atmosphere is usually found to be positively electrified, and its electricity is stronger in the winter than in the summer; and during the day than in the night.

Electricity (from *electrum*, amber), was a name given at first to some peculiar effects observed on rubbing that substance, and gradually extended to an immense collection of facts of a similar kind, as well as to the cause of these effects, whatever it may be, and to the science which investigates their laws.

This science is sometimes divided into five or six branches, according to the modes in which electric effects may be brought about. The term *atmospheric* electricity applies to that which is naturally exhibited at nearly all times, but especially in thunder-storms; *common* or *frictional* electricity, to that developed by mere mechanical actions; *galvanism* or *voltaic* electricity, to that developed by chemical action; *thermo*-electricity, by the action of heat; *magneto*-electricity, by that of magnetism; and *animal* electricity, by the will of certain fishes, which use this power as a defence. A more modern and comprehensive division is into—1. *Electro-statics*, or *tensional* electricity, referring to those effects in which the agency seems to have the equilibrium of its distribution disturbed, so as to be excessive or deficient in certain bodies, making them appear in different *states*. 2. *Electro-dynamics*, or *current* electricity, describing those effects in which the agency appears to be moving from place to place, and displaying *momentum*.

Electrum, from the Greek, a name given to amber, or to a mixture of metals composed of gold and silver

Electrum, argentiferous gold; an alloy of silver

Elegance, in a design, is a manner which embellishes and heightens objects, either as to their form or colour, or both, without destroying or perverting truth

Elementary Instruction. Before entering into practice, it will be necessary to bear the following rules and tables always in mind; and although we are to suppose every one already well acquainted with

them, they may yet possibly be found useful and essential here.

SIGNS AND MARKS.

+ Plus, or more: the sign of addition; as $5+6=11$
− Minus, or less: the sign of subtraction, as $20-5=15$
× Multiply by: the sign of multiplication, as $8\times 9=72$
÷ Divide by: the sign of division, as $16\div 4=4$
= Equal to: the sign of equality, as 27 cubic feet = 1 cubic yard
:: Proportion: the sign of proportion, as 3 : 6 :: 8 : 16
$\frac{27}{18}$ Fraction
$\sqrt{}$ Square root. $\sqrt[3]{}$ Cube root

LINEAL MEASURE.

7·92 inches	1 link
12 inches	1 foot
3 feet	1 yard
5½ yards .	1 rod, pole, or perch
4 poles, 100 links .	1 chain
40 poles, 10 chains .	1 furlong
8 furlongs, 1760 yards,	1 mile
80 chains, 8000 links	1 mile

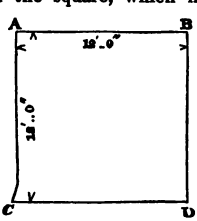
SQUARE OR SUPERFICIAL MEASURE.

144 square inches .	1 square foot
9 square feet . .	1 square yard
30¼ square yards	1 square pole or perch
40 perches . . .	1 rood
4 roods . . .	1 acre
640 acres	1 square mile

CUBIC OR SOLID MEASURE.

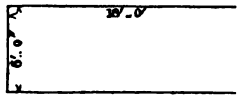
1728 solid inches .	1 cubic foot
27 solid feet . .	1 cubic yard

Proceeding to the various forms of plane surfaces, and the methods of measuring them, and beginning with the square, which has four



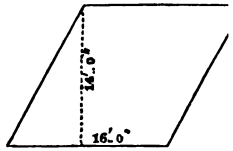
equal sides and four right a
as A, B, C, D,—Rule: Multi
given side by itself, and the p
is the area required. Ex. 1
=144.

The next figure will be a
lelogram, or oblong square.
Multiply the length by the br



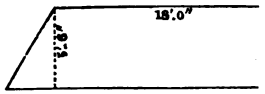
and the product gives the
Ex. 18′ 0″ × 6′ 0″ = 108′ 0″

The next figure will be a
bus, which has four sides all
but no right angle. Rule:



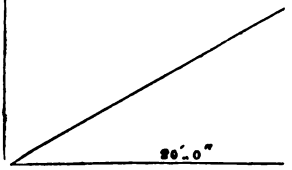
ply the base by the perpen
height, and the product is th
Ex. 16′ 0″ × 14′ 0″ = 224′ 0

The next figure will b
rhomboid, which has its tw
equal and parallel, but no
angle: it is a long square



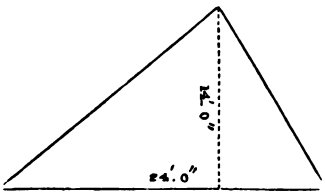
aside. Rule: Multiply the
side by the perpendicular
or breadth, and the product
area. Ex. 18′ 0″ × 5′ 6″ = 99

The next will be a right-
triangle, having one of its a
true square, or just 90 d



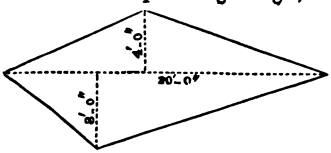
Rule: Multiply one of the legs forming the right angle by half the other; the product is the area. Ex. 16′ 0″ ÷ 2 = 8′ × 20′ 0″ = 160′ 0″.

The next figure will be a triangle. Rule: Multiply the longest side by one-half the perpendicular,



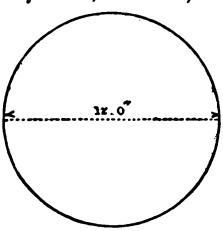
and the product is the content. Ex. 14′ 0″ ÷ 2 = 7′ 0″ × 24′ 0″ = 168′ 0″, area required.

The next figure will be the trapezium, which consists of four unequal sides and four unequal angles; it is, indeed, two triangles, and may be measured at twice, as shown in the preceding triangle, or



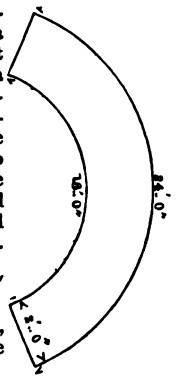
by this Rule: Multiply the diagonal by one-half the sum of the two perpendiculars. Ex. 8′ 0″ + 4′ 0″ = 12′ 0″ ÷ 2 = 6′ 0″ × 20′ 0″ = 120′ 0″, the area required.

The next figure will be the area of a circle. Rule: Square the diameter, and multiply that product by ·7854, a decimal, and that

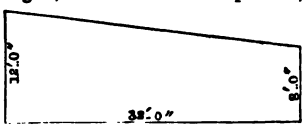


product will be the content. Ex. 12′ 0″ × 12′ 0″ = 144′ 0″ × ·7854 = 113·0976.

The next diagram will be a segment or part of a section of a circle: to measure this, multiply half the sum of the two arches by one of the ends, and the product will give the area. Ex. 24′ 0″ + 18′ 0″ = 42′ 0″ ÷ 2 = 21′ 0″ × 2′ 0″ = 42′ 0″, which is the area required.



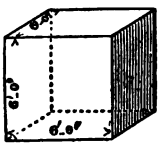
Where the figure is found of the shape annexed, with two right angles, and the sides not parallel,

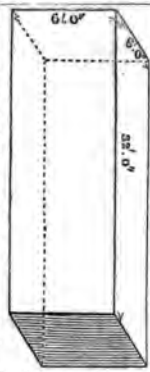


instead of dividing it and measuring it as a parallelogram and an angle, take the mean of the two perpendiculars, and multiply by the length; the product will give the area required. Ex. 12′ 0″ + 8′ 0″ = 20′ 0″ ÷ 2 = 10′ 0″ = × 32′ 0″ = 320′ 0″.

It is now necessary to take into consideration the methods of measuring solid or cubic bodies; for example, to begin with a cube, viz. a solid bounded by six square sides, similar to a die.

Rule: Multiply the side by itself, and that product by the side again; the last product will be the solid content. Ex. 6′ 0″ × 6′ 0″ = 36′ 0″ × 6′ 0″ = 216′ 0″ cubic feet.

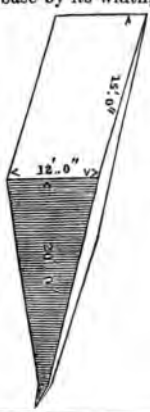


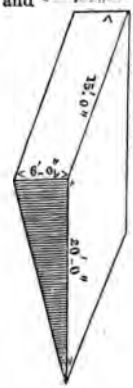


The next figure is the parallelopipedon, or oblong cube. Rule: — Multiply the breadth by the depth, and that product by the length; this last product will be the content of it. Ex. 6′0″ × 8′ 0″ = 48′ 0″ × 32′ 0″ = 1536′ 0″ = the required content of the parallelopipedon.

Next proceed to the prism, to measure which, find the area at the end, multiply that by the length, and that product is the content. Ex. The perpendicular height, 6′ 0″ ÷ 2 = 3′ 0″ × 12′ 0″ = 36′ 0″ × 32′ 0″ = 1152′ 0″.

The inclined plane and wedge may be measured by the same rule as the prism; but the readier way is to multiply one-half of the thickness of the base by its width, and



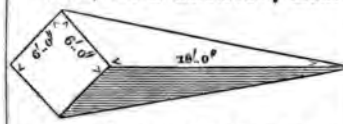


that by the perpendicular or length. Ex. 3′ 0″ × 15′ 0″ = 45′ 0″ × 20′ 0″ = 900′ 0″ = content of inclined plane.

This figure will be found in all earth-work, passing from cutting to embankment.

Again, 6′ 0″ × 15′ 0″ = 90′ 0″ × 20′ 0″ = 1800′ 0″, content of the wedge.

The next figure is a square pyramid, and the one-half of which is a very prominent formation in banks, and is measured by multi-



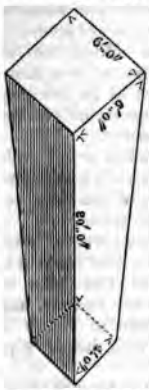
plying the area of the base by one-third the height or length. Ex. 6′ 0″ × 6′ 0″ = 36′ 0″ × 6′ 0″ = 216′ 0″ content.

Arriving now at the cylinder, this is measured by multiplying

the area of the base or end by the length. Ex. 12′ 0″ × 12′ 0″ = 144′ 0″ × ·7854 = 113·0976 × 20′ 0″ = 2260′ 0″.

The cone is also measured by multiplying the area of the base by one-third the perpendicular height. Ex. 12′ 0″ × 12′ 0″ = 144′ 0″ × ·7854 = 113′ 0″ × 6′ 8″ = 753′ 4″.

The next figure is the frustrum of a square pyramid, which also is a form peculiar in embankments and cuttings. Rule: To four times the area of the mean base add the area of each end, which divide by 6; multiply the product by the length, you will find the contents. Ex. 4′ 0″ + 6′ 0″ = 10′ 0″ ÷ 2 = 5′ 0″, the mean height of the base or thickness will be 5′ 0″; 5′ 0″ × 5′ 0″ = 25′ 0″ × 4′ 0″ = 100′ 0″ + 36′ 0″ = 136′ 0″ + 16′ 0″ = 152′ 0″; 152′ 0″ ÷ 6′ 0″ = 25′ 4″ × 20′ 0″ = 506′ 8″ content.



The same rule applies to the frustrum of a cone.

Elizabethan Architecture, the style which prevailed in England at the time of Queen Elizabeth, and immediately subsequent to the Tudor style of Henry VIII.

Ellipse: this curve is one of the conic sections, and next in importance to the circle and the straight line

Ellipsis, an oval figure generated from the section of a cone by a plane cutting both sides of the cone, but not parallel to the base, and meeting with the base when produced

Elliptic compasses, a term given to any machine for describing ellipses

Elliptograph, an instrument for drawing ellipses

Elm, a timber-tree, of European growth, and of which there are five species: mean size, 44 feet long, 32 inches diameter: it is not liable to split, and bears the driving of nails, bolts, &c.: much used in building; also for the keels of vessels, and for wet foundations.

Elongation, the act of lengthening

Elutriation, the separation of foul substances from pure, by pulverization

Elvan, (in Cornish), a hard close-grained stone, said to be a bastard limestone

Embankments, raised mounds or dykes to preserve the proper and useful course of rivers, &c.; and also for forming a level line of railway

Embankments (some) executed on the Continent. On the banks of the Po, two sorts of dykes are used to prevent the river from overflowing during the winter, or the flood season. They are called 'in froldi' when immediately upon the banks of the river, and 'in golene' when at any considerable distance, as it is sometimes found advisable to allow the river to spread over a large surface of the adjacent valley, either for the purpose of admitting it to deposit the mud in suspension, or to allow it to lose its torrential character. The maintenance of the works of these dykes is confided to the Government engineers, who are under the control of a syndicate of the proprietors of the property most liable to be affected by inundations. When the river passes from one state to another, as from Piedmont to Modena, a mixed commission is charged with the joint superintendence.

The Haarlem lake, besides the very remarkable steam engines described by Mr. Dempsey, merits observation for the extensive works executed for the defence of the land, and for the canals reserved for the navigation. The enclosure dyke is 50,000 metres long, or rather more than 31 miles. It has two outfall dykes, which serve for the navigation, 9000 metres, about 5½ miles; one-half of which is 40^{m}·(131 ft. 2 in.) wide at the bottom or floor line; the other 43^{m}·20 (141 ft. 10 in.)

The ordinary tides are, at the flux, 2 ft. 4 in. above the scale or datum line at Amsterdam; at the reflux, 2 ft. 8 in. below the same datum: the difference between high and low water is then, on the

average, about 5 feet. With violent winds from the N.W. however, the tides rise sometimes 6 ft. 6 in. above the average. The tides of the Y, near the lake, are + 16c. (or 6½ in.) and – 23c. (or 9 in.), giving a total variation of 1 ft. 3½ in.

The estimated cost of reclaiming the 18,000 hectares was 8 millions of florins, or £667,000 English, nearly, about £13 per acre. Previously to undertaking this colossal work, the Zind Plas, of 4600 hectares superficial (nearly 11,500 acres), had been reclaimed at a cost of 3 millions of florins, or £250,000; not far from £22 per acre.

The heights of the enclosure dyke are + or – the datum line at Amsterdam, or the mean level of the sea in that port.

Embankment of the flooded part of the Amsterdam and Haarlem Railway.—The bottom part consists of treble ranges of fascines, tied down by longitudinal poles 1 metre apart from centre to centre, and 0·25c. diameter; two double stakes at each end of the poles, and two ties in the intermediate distances. The interstices of the fascines and the space between the rows are filled in with sand. The upper part, forming the encasement for the ballast, is made of three rows of treble fascines, well staked, and wattled together.

A core of sand or clay, faced with step fascines, is made up to low-water mark. Upon this a bed of rushes, fastened down by stakes and wattles, is laid; and the upper portion of the bank is faced with fascines of a regular slope of 1 to 1.

Embattled, a term applied to any building with a parapet, and having embrasures to resemble a battery

Emblema, an emblem, or inlaid ornament of divers colours

Embolus, in mechanics, a wedge; anciently, among the Greeks, the prow or beak of a vessel, or a body of soldiers in the form of a wedge

Embossing, forming work in relievo, whether cast or cut with a chisel; or in modern times, the art of producing raised figures upon wood or other materials by means of pressure, either applied by a sudden blow, as in a stamping press, or in a more gradual manner, as by an ordinary screw or hydraulic press, or by means of revolving cylinders

Embrasure, the crenelles or intervals between the merlons of a battlement

Embroidery, a mode of working devices on woven substances

Emerald green is a new colour of copper green upon a terrene base: it is the most vivid of this tribe of colours, being rather opaque, and powerfully reflective of light: it appears to be the most durable pigment of its class

Emissarium, a sluice, flood-gate, or channel by which an outlet is formed to carry off stagnant or foul water: according to Pliny, an artificial canal formed for the draining of stagnant waters

Emplecton, a method of constructing walls introduced by the Greeks and copied by the Roman architects, in which the outside surfaces on both sides were formed of ashlar laid in regular courses, and the central space between them filled in with rubble-work, layers of cross stones being placed at intervals in regular courses, and of sufficient size to extend through the entire thickness of the wall from side to side, and so act as girders to bind the whole together

Emporium, a mart or factory, a large building containing ranges of bonding warehouses, in which foreign merchandise brought by sea is deposited for sale

Enamelling, the art of using enamel, which is divided into transparent and opaque. The first is employed for the purpose of ornamenting gold and silver; the second, commonly in the manufacture of watch and clock dials, and of plates for pictures, &c.

Encarpa, according to Vitruvius, fes-

toons of carved fruit and flowers, employed as decorative ornaments

Encarpus, a festoon of fruit, flowers, &c., used as ornaments on friezes

Encaustica, the art of encaustic painting, *i. e.* in colours mixed with wax, and afterwards hardened by the action of fire

Encaustic painting, a kind of painting in which, by heating or burning in, the colours are rendered permanent in all their original splendour

Enchasing, the art of enriching and beautifying gold, silver, and other metal work, by some design or figure represented thereon in low relievo

Enclosure, a fence, a wall, or hedge, or other means of protection and security surrounding land

Endecagon, in geometry, a plane figure of eleven sides and angles

End-irons, andirons or dogs, articles of household furniture in earlier times, used in fire-places to sustain the ends of logs of wood

Engineering, Civil. This profession may be said to have originated in England about the middle of the last century. Before that period, whenever the prospects of great profit induced individuals or bodies to incorporate themselves for the purpose of undertaking extensive systems of drainage, or for the supply of water, requiring the assistance of an engineer, recourse was generally had to those great masters of hydraulic engineering, the Dutch. True it is that some solitary exceptions have occasionally been found; men who, like Sir Hugh Myddelton, combined a speculative turn of mind with some mechanical knowledge, and to these two qualities added an untiring energy of purpose, leading them to persevere in any undertaking, even under the most discouraging circumstances. But these men were rare instances of a peculiar talent, which, though it thus displayed itself occasionally, was far too uncommon a gift to allow the possessors of it to form a class or profession. The case is very different now: a demand for this peculiar talent has been created of late years by the extraordinary development of our system of internal communication, as well as by the application of steam to the purposes of our manufactures; and employment is now found for hundreds where one was sufficient, not fifty years since, for the whole business of the country. So great indeed has been the demand, that the profession may be said to be divided into two distinct bodies, viz. those who turn their attention to subjects which come more particularly within the scope of the duty of a civil engineer, such as docks, bridges, canals, railroads, &c., and those who devote themselves altogether to the manufacture of machinery. The duties which are involved in the practice of these two branches of the profession, though apparently dissimilar in character, are yet founded upon the same general principles; and the acquirements which are necessary to enable the individual of one class to distinguish himself, or even to practise his profession with a moderate chance of success, will be found equally necessary for those of the other class.

These acquirements are partly abstract and theoretical, and partly experimental or practical. A civil engineer should, in addition to the knowledge required to fit him as well as others for the active duties of life, have such a knowledge of mathematics as will enable him to investigate as well as to apply the rules laid down by writers on those branches of the mixed sciences to which his attention will most frequently be drawn. He should be well acquainted with the principles of mechanics, hydraulics, and indeed with all the branches of natural philosophy; and a certain amount of chemical knowledge will be found very valuable: he should be able to

draw neatly, and should understand the principles of projection upon which all engineering drawings are constructed: a general knowledge of the principles of architecture will also be essential. Having acquired the requisite amount of theoretical information, the next step is to gain that practical knowledge which is essential in order to the proper application of this information. The best mode of gaining this experience is to enter into the employment of some eminent man in the profession, in whose office there will be every opportunity offered to the young beginner of witnessing the mode in which the various descriptions of work are carried on. He will there be employed, first as a draughtsman, in copying drawings: as he becomes more acquainted with practical details, he will have more responsibility thrown upon him, and be placed in charge of works, at first of small importance, but, by degrees, of those of such magnitude as will require all his theoretical knowledge, and all the practical experience he may have gained, to enable him to carry out the work to the satisfaction of his employers: he should cultivate a habit of observation, and make a point of taking ample notes and sketches of whatever he may see which in any way bears upon his profession. Having thus by degrees acquired a sufficient amount of information to give him a confidence in his own judgment upon any subject which may be submitted to him, and having become known as an active and intelligent agent of others, he will very possibly be called upon to plan and execute a work himself, and then, by degrees, with industry and activity, may work his way upwards in *a profession where merit alone can lead to distinction.*

The course of the man who devotes himself to the machinery branch of the profession differs but *little, up to a certain point,* from that just described: his theoretical acquirements should be the same, but the practical part of his education will commence at the bench, where he will learn the use of all the tools and machinery by working at them with his own hands: he will then be placed in the drawing room, and go through much the same routine of instruction as before described, and will by degrees work his way up to the position of foreman; then, distinguishing himself by a power of applying general principles to particular cases, he will show himself capable of assuming the direction of an establishment for the manufacture of machinery.

Engineer, Steam-boat. A steam-boat engineer is a person employed for the purpose of keeping the engine or engines of a steam vessel in as efficient a state as possible, and to superintend their working.

He must set the engines to work, regulate their speed, and stop them as may be required. His duties while the engines are at work are various. He must take care that every moving part is properly lubricated; that no steam is allowed to pass through valves or joints that ought to be steam-tight; that no air is permitted to enter into any of the parts of the engine where it is essential that a vacuum should be kept up; and that none of the bolts, or pins, or keys, work loose by the vibration, and shift their position, or come out of their places. He must also take care that none of the working parts become overheated by any undue amount of friction, arising from any want of proper lubrication, any excessive tightness, or any other disturbing cause; and if they should become overheated, he must take prompt and energetic measures to remedy the evil, and prevent any serious consequences arising therefrom. He must from time to time carefully observe the effect produced by the gradual wear of the working parts, so that if the

truth or accuracy of any of these seems to be materially affected, he may take steps to rectify the defects when lying up in harbour. He must also be careful to observe if the frame of the engine ever begins to move or work in any way, and endeavour to discover the cause, in order that it may be remedied when the engines are at rest. One of the most important of his duties is to take care that the engines are kept clean, and any grit or dirt prevented from getting into the bearings or moving parts: he must wipe away all oil and grease most carefully and completely as soon as they have passed through the bearings, and prevent them from running down the rods or remaining about the engine.

The boiler requires his unremitting and particular attention, in order that the proper supply of steam, neither too much nor too little, may be generated for the engine. To insure this, the management of the fires must be duly attended to, both in the supply of coal in the proper quantities at the proper intervals, and in the periodical clearing of the fires from the earthy matters of the coal, which may have become vitrified in the furnace, and formed what are called clinkers. By due attention to the former, the smoke in all well-proportioned boilers may be very greatly abated; and, by due attention to both, the consumption of fuel (when the engines are prevented by a strong head wind, or by the deep immersion of the paddle-wheels on the commencement of a long voyage, from making the proper number of strokes, and thus using the proper amount of steam,) may be reduced in an equal or greater degree than has taken place in the consumption of steam. The due and constant supply of water to the boiler, to compensate for the constant evaporation of the water in the formation of the steam, must be assiduously attended to. Another of the most important of the duties of a steam-boat engineer, during the time that the engines are at work on a voyage at sea, is to attend to the degree to which the water in the boilers may become saturated with salt by the continued evaporation which is going on, and to take care that this saturation is not allowed to be carried to such an extent as that a deposition of the salt and other matters contained in sea-water should take place. After the boilers have been in operation for three or four hours in salt water, so that the water in them has become brine, he ought to test the strength of it, that is, he ought to ascertain the degree of saturation to which it has reached, and continue this examination periodically, whether the engines are fitted with an apparatus for the continuous discharge of a portion of the brine, to be exchanged for a portion of sea-water, or whether this system of exchange is left entirely at his discretion, to be attended to by means of the common blow-off cocks. The best test is the common hydrometer, though the thermometer has hitherto been more commonly applied to this purpose, as the brine is considered to be of a proper strength when it boils under atmospheric pressure at a temperature 2° higher than that at which the common sea-water will boil at the same time, under the same circumstances.

Before coming into port, it may occasionally be advantageous to take indicator diagrams, to see whether the action of the valves *continues* to be correct.

The duties of a steam-boat engineer, on arriving in port after a long voyage, are also various, and equally important with those he has to perform when out at sea. Immediately on coming to anchor, it is a good practice to test the tightness of the steam-valves and pistons, by putting them in such a position

that it can be seen if they allow any steam to pass when it ought not to do so. If any imperfections in these the most vital parts of the engines are discovered, he must draw out the valves, or lift the cylinder covers, to get at the pistons, and rectify the defects in the best manner that he can with the means within his power. He should also occasionally examine all the interior parts of the engines, and rectify any incipient defects. He must now also rectify any want of truth in the parallel motion or in any of the shafts or working parts caused by wear, and tighten or make good any of the fastenings of the frame if he has found them to be loose, and put to rights any other such defects. Any parts subject to corrosion should be carefully examined, cleaned, and dried, and painted if need be. The water should be blown off out of the boilers as completely as possible, and all ashes and soot thoroughly cleaned out of the furnaces and flues as soon as possible. The furnaces and flues must then be thoroughly examined, and the slightest leak or defect that can be discovered made good; as it is especially important in a boiler to stop these defects at the first, as otherwise they spread very rapidly. No pains should be spared to discover any suspected leak of steam on the top of the boiler, as nothing tends more to corrode and destroy a boiler than this. Inside the boilers, any scale that may have been deposited from the brine having been allowed to become too strong must be removed, and the whole thoroughly cleaned out from every part of the boiler, from below as well as from the tops and sides of the furnaces and flues. The take-up, the inside of the steam-chests, and of the roofs of the boilers, which are the parts most subject to corrosion from the interior, should be very carefully examined, and after being duly scraped and cleaned *and dried*, they should be well painted with two or three coats of red lead, or done over with some other preservative.

The paddle-wheels should also be thoroughly examined, and any broken floats or hook-bolts replaced by new ones. The whole of the iron-work should be thoroughly scraped and cleaned, and, when dry, painted with three coats of red lead, or done over with black varnish, once every four months at least. When in harbour, especially if lying in a stream or tideway, the wheels ought to be turned round every three or four days, to change the parts exposed to the action of the water, and thus prevent corrosion.

He must now also get his supply of stores made good, so as to be ready for another voyage.

To qualify an engineer to perform these duties, he should be trained as a mechanic, and be a fair workman in iron, brass, and wood. He should be able to work not only at the lathe or vice, but also at a smith's forge. His education should be such as to make him able to keep accounts, and make notes in his log of all that occurs in the engine-room. He should have sufficient knowledge of mechanical drawing to enable him, in the event of any important part of the engines being broken when at a distance from any manufactory, to make such a drawing of it as would enable a manufacturer to replace it. He should have some knowledge of the first principles of mechanics, a general knowledge of the leading principles of hydrostatics, hydraulics, and pneumatics, without which he cannot fully understand many of the principles carried on in the engine, and on which its power depends. Some knowledge of heat, of the theory of combustion, of ebullition, and of evaporation, may also be reckoned as almost indispensable: to which should be added, if possible, an acquaintance with the subject of steam, especially as regards

its temperature, pressure, and latent heat.

Engineer, Mechanical, one who is efficient in the invention, contrivance, putting together, and the adjustment of all kinds of machinery; who is acquainted with the strength and quality of the material used, and who also possesses a thorough knowledge of the power of steam and the engine in all its modifications, and the uses for which this motive power is applied: he should also be duly acquainted with mill-work of the several kinds, whether impelled by steam, water, or wind.

English School of Painting. This school, which is but of recent date, is connected with the Royal Academy in London, instituted in 1766; and although as a school it did not exist before that period, yet since the revival of the arts, and the consequent encouragement given to them by the sovereigns of Europe, England has possessed portrait-painters of no inconsiderable ability; and it is probably owing to the remarkable partiality of the nation for this branch of the art, that historical painting has been, until recently, comparatively neglected. Latterly, however, painters of the highest eminence in this superior branch of the art have distinguished themselves, and given earnest of the rise of a school that may, ere long, surpass others of the present age.

Entablature, those members of a portico which were constructed upon the columns, consisting of the epistylium, zophorus, and corona. Vitruvius uses the words *ornamenta columnarum* to signify these members; and sometimes he includes the three several parts in the term *epistylia*.

Entablature, the superstructure that lies horizontally upon the columns in the several orders or styles of architecture. It is divided into architrave, the part immediately above the column; frieze, the central space; and cornice, the upper projecting mouldings. Each of the orders has its appropriate entablature, of which both the general height and the subdivisions are regulated by a scale of proportion derived from the diameter of the column.

Entablatures, and their subdivision. The entablature, though architects frequently vary from the proportions here specified, may, as a general rule, be set up one-fourth the height of the column. The total height thereof thus obtained is in all the orders, except the Doric, divided into ten parts, three of which are given to the architrave, three to the frieze, and four to the cornice. But in the Doric order the whole height should be divided into eight parts, and two given to the architrave, three to the frieze, and three to the cornice. The mouldings which form the detail of these leading features are best learned by reference to representations of the orders at large. Palladio and Vignola, the restorers of genuine architecture, are the authors whose works may be consulted with greatest advantage by those who desire to make any advance in the science, and most particularly by those who wish to obtain further knowledge on the use and abuse of its details.

Entail, a term used in the middle ages to signify elaborated sculptured ornaments and carvings

Entasis, the swell of the shaft or columns of either of the orders of architecture

Enterclose, a passage between two rooms in a house, or that leading from the door to the hall

Entresol, in architecture, a floor between two other floors. The entresol consists of a low apartment usually placed above the first floor: in London, frequently between the ground floor and the first floor.

Ephebeum, an apartment in the palæstra appropriated to wrestling and other athletic exercises

Epicycle, a little circle whose centre is in the circumference of a greater

Epicycloid, a curve generated by the revolution of the periphery of a circle along the convex or concave part of another circle

Epicycloidal wheel, a wheel for converting circular into alternate motion, or alternate into circular

Episcenium, a division of the scene of a Greek theatre: it sometimes consisted of three divisions made by ranges of columns one above the other: the lower was termed *scena*, and the others *episcenia*

Epistomium, the cock or spout of a water-pipe, or of any vessel containing liquids to be drawn off in small quantities when required

Epistylium, the lower of three divisions of an entablature or superstructure upon the columns of a portico, formed by pieces etxending from centre to centre of two columns

Epistylium, the architrave or horizontal course resting immediately upon columns. *Epistylar arcuation* is the system in which columns support arches instead of horizontal architraves and entablatures.

Epitithidas, a term applied by some writers, by way of distinction, to the cymatium on the sloping or *raking* cornices of a pediment, which *superimposed* moulding (as its name implies) was frequently largely developed, and enriched with an ornamental pattern

Epitithides, the upper members of the corona surmounting the fastigium of a temple, which was also continued along the flanks

Equation, an equal division: in algebra, a mutual comparing of things of different denominations: in astronomy, the difference between the apparent and mean motion of the sun

Equilateral, having all sides equal

Equilibrium, equipoise, equality of weight

Equilibrium valve, the valve in the steam passage of a Cornish engine for opening the communication between the top and bottom of the cylinder, to render the pressure *equal* on both sides of the piston

Era. The year 5611 of the Jewish era commences September 7, 1850; Ramadân, the month of abstinence observed by the Turks, July 11, 1850; the year 1267 of the Mohammedan era, Nov. 6, 1850; and the Christian era, 1849 since the birth of Jesus Christ, for 1850 years, on the 1st of January, 1850.

Ergastulum, a sort of prison or house of correction contiguous to the farms and country villas of the Romans

Ergata, a capstan or windlass

Ermine, in heraldry, a white field or fur, powdered and interspersed with black spots, resembling the skin of an animal so named

Escape, the scape of a column in architecture

Escutcheon, a shield charged with armorial bearings

Etching, a branch of engraving in which the lines are drawn by a stylus or etching-needle, on copper, steel, or stone, prepared by a chemical process

Eudiometer, an instrument used to ascertain the purity of air, or rather the quantity of oxygen contained in any given bulk of elastic fluid

Euripus, any artificial canal or water-course, of greater or lesser extent, such as were made, according to Pliny, to ornament a Roman villa; also an arm of the sea

Eustyle, that intercolumniation which, as its name would import, the ancients considered the most elegant, viz. two diameters and a quarter of the column. Vitruvius says, this manner of arranging columns exceeds all others in strength, convenience, and beauty

Evaporation, the transformation of a liquid into a gaseous state by the action of heat

Evolute, a particular species of curve

Evolution, in geometry: the equable evolution of the periphery of a circle, or any other curve, is such a gradual approach of the circumference to rectitude as that all the parts meet together, and equally evolve or unbend

Bury, an office of household service, where the ewers, &c., were formerly kept

Examen, the tongue on the beam of a balance, rising perpendicularly from the beam, and moving in an eye affixed to the same, by which it serves to point out the equality or inequality of weight between the objects in the scale

Exedra, an assembly-room or hall of conversation; according to Vitruvius, a large and handsome apartment; also a by-place, or jutty

Exedra, or *Exhedra*, the portico of the Grecian palæstra, in which disputations of the learned were held: so called from its containing a number of seats, generally open, like the pastas or vestibule of a Greek house

Exemplar, a pattern, plan, or model; resemblance

Exhaust-port, the exit passage for the steam from a cylinder

Exhaust-valve, the valve in the eduction passage of the steam cylinder of a Cornish engine, placed between the cylinder and air-pump, and worked by the tappet motion, so as to open shortly after the equilibrium valve, and admit the steam to the condenser

Expansion joint, a stuffing-box joint connecting the steam pipes, so as to allow one of them to slide within the enlarged end of the other when the length increases by expansion

Expansion valve, an auxiliary valve placed between the slide-valve and the steam cylinder: it is worked by a cam or other contrivance, so as to cut off the steam at a given period, and cause the remainder of the stroke to be performed by expansion

Expansive steam. The expansive properties of steam are now well understood, and extensively applied to practice in manufacturing districts. In Cornwall, and in some other parts of the kingdom, the application is attended with highly beneficial results. But it should be stated that this system can be introduced with much greater advantage in engines that are employed in raising water, than in those which are entirely devoted to manufacturing purposes. In these last, the power is opposed to a continually varying resistance; while, in the former, the resistance is commonly the same, or of equal intensity.

To pumping engines, the adoption of the expansive system to an almost unlimited extent is recommended, even to the exclusion of any further ingress of steam to the cylinder after the piston has passed through but one-eighth or one-ninth of its stroke.

Expansive steam may be thus explained:—If we allow steam to flow into the cylinder of a steam engine until the piston be depressed to one-half of the stroke, and then prevent the admission of any further quantity, the piston will, if the engine be properly weighted, continue its motion to the bottom. The pressure of the steam, so long as the supply is continued from the boiler, will be equal, it is presumed, to ten pounds upon the inch. With this force it will act upon the piston until it completes one-half of the stroke: the further supply of steam will then be excluded, and that which is in the cylinder will expand as the piston descends, so that when the stroke is completed it will occupy the entire capacity. The pressure of the steam will then be half of its former amount, or five pounds upon the inch.

During the descent of the piston, the pressure of the steam does not suddenly decrease from ten pounds to five; but it gradually declines, through the successive intervals, until at the final point it yields that force. It is by this gradual expansion and diminution of pressure that the superior action is produced.

Experiments on Brass. Dr. Young made some experiments on brass,

from which he calculated the height of the modulus of elasticity of brass plate to be 4,940,000 feet, or 18,000,000 lbs. for its weight to a base of 1 square inch. For wire of inferior brass he found the height to be 4,700,000 feet.

As cast brass had not been submitted to experiment, a cast bar of good brass was procured, with which the following experiment was made:

The bar was filed true and regular: its depth was 0·45 inch, and breadth 0·7 inch; the distance between the supports was 12 inches, and the scale suspended from the middle.

lbs.		inch.	
12	bent the bar	0·01	
23	. . .	0·02	
38	. . .	0·03	The bar was relieved several times, but it took no perceptible set.
52	. . .	0·04	
65	. . .	0·05	relieved, the set was ·01.
110	. . .	0·18	
163	. .		slipped between the supports, bent more than 2 inches, but did not break.

Hence 52 lbs. seems to be about the limit which could not be much exceeded without permanent change of structure. It is equivalent to a strain of 6700 lbs. upon a square inch, and the corresponding extension is $\frac{1}{1888}$ of its length. Absolute cohesion above 21,000 lbs. per square inch. The modulus of elasticity according to this experiment is 8,930,000 lbs. for a base of an inch square. The specific gravity of the brass is 8·37, whence we have 2,460,000 feet for the height of the modulus.

Expression principally consists in representing the human body and all its parts in the action suitable to it; in exhibiting in the face the several passions proper to the *figures, and* marking the motions they impress on the other external parts

Expression, in painting, consists in the representation of those attitudes of the body, and variations of the countenance, which always accompany and indicate the immediate influence of the passions on the mind

Expression of colour. Every passion and affection of the mind has its appropriate tint; and colouring, if properly adapted, lends its aid, with powerful effect, in the just discrimination and forcible expression of them: it heightens joy, warms love, inflames anger, deepens sadness, and adds coldness to the cheek of death itself.

External thermometer (the) should be a mercurial one, well exhausted of air, and the graduated scale divided to tenths of a degree, or into quarters of a degree, or with whole divisions large enough to be divided into as many parts by the eye. Choose a locality for the instrument, where it will be well exposed to the ambient air,—apart from the reflection of sunbeams, &c.,—and where it may be distinctly read off without inconvenience. It should be read off as quickly as possible. For uniformity of system, it should be read off at stated periods, the same time at which the barometer, &c., are noted, and carefully watched in the interim, to see whenever any remarkable change occurs; before and after storms, during eclipses of the sun and moon, or the passage of dense clouds of vapour, &c.

Extract of gamboge is the colouring matter of gamboge separated from its greenish gum and impurities by solution in alcohol and precipitation, by which means it acquires a powdery texture, rendering it miscible in oil, &c., and capable of use in glazing. It is at the same time improved in colour, and retains its original property of working well in water and gum.

Extrados, the exterior curve of an arch, measured on the top of the voussoirs, as opposed to the soffit or intrados

Eye, a name given to certain circular parts and apertures in architecture, but more especially to the central circle of the Ionic volute; to the circular or oval window in a pediment; to a small skylight in a roof, or the aperture at the summit of a cupola

FAB

FABER, a name given by the Romans to any artisan or mechanic who worked in hard materials

Fabrica, according to the Romans, the workshop of any mechanic

Fabrilia, according to Horace, mechanics' tools

Façade, the face or front of any considerable building to a street, court, garden, or other place

Face-piece, in ship-building, a piece wrought on the fore-part of the knee of the head, to assist the conversion of the main-piece, and to shorten the upper bolts of the knee of the head

Fahrenheit, a native of Dantzic, was born in 1686: he invented the scale so called after his name: he also improved the thermometer by substituting mercury instead of spirits of wine, and formed a new scale for the instrument, founded on accurate experiments, fixing the freezing point of water at 32°, and that of boiling at 212°

Faldstool, or folding stool, a portable seat made to fold up in the manner of a camp stool: it was made either of metal or wood, and sometimes covered with rich silk

False roof, the space between the ceiling and the roof above it, whether the ceiling is of plaster or a stone vault, as at King's College chapel, Cambridge, and St. Jaques' church, Liége

Fan-tracery vaulting: this was used in late Perpendicular work, in which all the ribs that rise from the springing of the vault have the same curve, and diverge equally in every direction, producing an effect like the bones of a fan: very fine examples of it exist in Henry the

FAR

VIIth's chapel, Westminster, St. George's chapel, Windsor, and King's College chapel, Cambridge

Fanal, a pharos or lighthouse, or the lantern placed in it

Fanum, a Roman temple or fane, usually consecrated to some deity

Fang, in mining, a niche cut in the side of an adit, or shaft, to serve as an air course: sometimes a main of wood pipes is called a fanging

Fanners, vanes or flat discs revolving round a centre, so as to produce a current of air; generally used instead of bellows for forges

Farm. Vitruvius says—"The magnitude of the buildings must depend wholly upon the quantity of land attached to them, and upon its produce. The number of courts and their dimensions must be proportioned to the herds of cattle and the quantity of oxen employed. The kitchen should be situated in the warmest part of the court, and the stable for the oxen contiguous to it: the stalls should be made to face the hearth and the east; because when oxen are constantly exposed to light and heat, they become smooth-coated. No husbandman, however ignorant, will suffer cattle to face any other quarter of the heavens than the east. The width of the stables ought not to be less than ten nor more than fifteen feet, their length proportioned to the number of yokes, each of which should occupy an extent of seventeen feet. The scalding-rooms should adjoin the kitchen, in order that the operation of cleaning the utensils may be performed upon the spot. The courts for sheep, &c., should be

so spacious as to allow not less than four and a half nor more than six feet to each animal.

"The granaries should be above ground, and made to front either the north or the north-east, in order that the grain may not be liable to ferment; but, on the contrary, by exposure to a cold atmosphere, may be preserved a long time: all other aspects encourage the propagation of worms and insects destructive to grain. The stables should be built in the warmest part of the villa, most distant from the hearth; because when horses are stalled near fire they become rough-coated. It is likewise expedient to have stalls for oxen at a distance from the kitchen, in the open air: these should be placed so as to front the east, because if they are led there to be fed in winter, when the sky is unclouded they will improve in appearance. The barns, the hay-yards, the corn-chambers, and the mills, ought to be without the walls; so that the farm may be less liable to accidents from fire."

Farm, in Cornish mining, that part of the lord's fee which is taken for liberty to work in tin mines only that are bounded, which is generally one-fifteenth of the whole

Fascia, a flat architectural member in an entablature or elsewhere; a band or broad fillet. The architrave in the more elegant orders of architecture is divided into three bands, which are called fasciæ: the lower is called the first fascia, the middle one the second, and the upper one the third fascia.

Fasciæ, the bands of which the epistylium of the Ionic and Corinthian orders are composed. The antepagments of Ionic doorways were generally divided into three fasciæ or corsæ. Fasciæ were bands which the Romans were accustomed to bind round the legs.

Fast and loose pulleys, two pulleys placed side by side on a shaft which is driven from another shaft by a band: when it is required to stop the shaft, the band is transferred to the loose pulley

Fastigium, the pediment of a portico; so called because it followed the form of the roof, which was made like a triangle, the sides being equally inclined to carry off the water

Fastigium, in architecture, the summit, apex, or ridge of a house or pediment

Faux, according to Vitruvius, a narrow passage which formed a communication between the two principal divisions of a Roman house, —the atrium and peristylium

Fay, in ship-building, to join two pieces of timber close together

Feathering, or *foliation*, an arrangement of small arcs or foils separated by projecting points or cusps, used as ornaments in the mouldings of arches, &c. in Gothic architecture

Feed-head, a cistern containing water and communicating with the boiler of a steam engine by a pipe, to supply the boiler by the gravity of the water, the height being made sufficient to overcome the pressure within the boiler

Feed-pipe, the pipe leading from the feed-pump, or from an elevated cistern, to the bottom of the boiler of a locomotive engine

Feed-pipe cocks, those used to regulate the supply of water to the boiler of a locomotive engine, and the handle of which is placed conveniently to open and shut at pleasure

Feed-pipe strainer, or *strum*, a perforated half-spherical piece of sheet iron, after the manner of the rose end of a watering pot: it is placed over the open end of the feed-pipe in the locomotive tender tank, to protect it

Feed-pipes, the copper pipes reaching from the clack-box to the pump and from the pump to the tender, to convey water to the boiler of a locomotive engine

Feed-pump, a forcing-pump, worked by the steam engine, for supplying the boiler with water

Feed-pump plunger, the solid piston, or enlarged end of the pump-rod, fitting the stuffing-box of the pump of a steam engine

Felling timber, the act of cutting down a full-grown tree, which doubtlessly should be done late in the autumn, when less moisture exists in all trees, and which renders the timber less liable to dry-rot

Felspar, a mineral of foliated structure

Felucca, in navigation, a little vessel used in the Mediterranean, capable of going either stem or stern foremost; also a small open boat, rowed with six oars

Femerell, a lantern, louvre, or covering placed on the roof of a kitchen, hall, &c. for the purpose of ventilation or the escape of smoke

Femur, in architecture, the long flat projecting face between each channel of a triglyph; the thigh, or a covering for the thigh

Fender-piles, those driven to protect work either on land or in water

Fenestella, the niche at the side of an altar containing the piscina; a vessel for holding water to wash the hands of the officiating priest; also a little window

Fenestra, a window, an entrance

Fenestral: window-blinds or casements closed with paper or cloth, instead of glass, are so termed

Fenestration, termed by the Germans *Fenster-architektur*, is, in contradistinction to columniation, the system of construction and mode of design marked by windows. Fenestration and columniation are so far antagonistic and irreconcileable, that fenestration either interferes with the effect aimed at by columniation with insulated columns, as in a portico or colonnade, or reduces it, as is the case with an engaged order, to something quite secondary and merely decorative. Astylar and fenestrated ought, therefore, to be merely convertible terms; but as they are not, that of *columnar-fenestrated* has been invented, to denote that mode of composition which unites fenestration with the *semblance*, at least, of the other. Employed as a collective term, fenestration serves to express the character of a building or design with regard to the windows generally: thus it is said, the fenestration is excellent, or the contrary,—ornate or meagre,—well arranged or too crowded,—which last circumstance is a very common fault, and is destructive both of grandeur and of repose.

Feretory, a bier, or coffin; a tomb, or shrine

Ferrule, a metal ring fixed on the handle of a tool to prevent the wood from splitting

Fesse, in heraldry, a band or girdle possessing the third part of the escutcheon over the middle

Festoon, an ornament of carved work, representing a wreath or garland of flowers or leaves, or both interwoven with each other: it is thickest in the middle, and small at each extremity, a part often hanging down below the knot

Festoon, in architecture, an ornament of carved work, in the form of a wreath or garland of flowers, or leaves twisted together

Fictile, an earthen vessel or other article, moulded and baked

Fictor, among the Romana, an artist, a deviser, or potter

Field, in heraldry, the whole surface of the shield

Figulus, an artist who makes figures and ornaments

Filagree, in the arts, a kind of enrichment in gold and silver

File, a well-known instrument having teeth on the surface for cutting metal, ivory, wood, &c.

File, a strip or bar of steel, the surface of which is cut into fine point or teeth, which act by a speci of cutting closely allied to a asion.

When the file is rubbed over the material to be operated upon, it cuts or abrades little shavings or shreds, which, from their minuteness, are called file-dust, and, in so doing, the file produces minute and irregular furrows of nearly equal depth, leaving the surface that has been filed more or less smooth, according to the size of the teeth of the file, and more or less accurately shaped, according to the degree of skill used in the manipulation of the instrument. The files employed in the mechanical arts are almost endless in variety.

Finial, sometimes called a pinnacle, but more truly confined to the bunch of foliage which terminates pinnacles, canopies, pediments, &c. in Gothic architecture

Finite force, a force that acts for a finite time, such as the force of gravity

Fillet, a small flat face or band, used principally between mouldings to separate them from each other in classical architecture: in the Gothic, Early English, or Decorated styles of architecture, it is also used upon larger mouldings and shafts

Finlayson's Tables of the value of life assurance and annuities differ in several respects widely from either the Northampton or the Carlisle calculated Tables. In framing them for Government annuities from observations made on the mortality in tontines and amongst the holders of Government annuities, Mr. Finlayson, in his calculations, is inclined to take a favourable view of the duration of human life, and his Tables coincide very nearly with the Carlisle, except that he makes a distinction between males and females,—the latter being considered rather longer lived than the former. As regards annuities, these observations may be thus illustrated: the present value of an annuity of £1 for the life of a person aged twenty-five, calculated at 4 per cent. interest, would be, according to the

	£.	s.
Northampton Tables,	15	4
Carlisle do. . . .	17	6
Government, Male .	16	9
Do. . . . Female.	18	1

Fire-bar frame, in a locomotive engine, a frame made to fit the fire-box on which the fire-bars rest: a plan of dropping all the bars at once by a moveable frame, acted on by a lever and handle outside the fire-box, has been frequently tried, but the action of the intense heat soon puts it out of working order

Fire-bars, in a locomotive engine, wedge-shaped iron bars fitted to the fire-box with the thick side uppermost, to support the fire: the ends rest on a frame: they are inclined inwards, with an air space between each, to promote combustion, and are jointed at one end, and supported by a rod at the other, so that the rod being withdrawn, the bars fall, and the fire-box is emptied

Fire-box, in a locomotive engine, the box (usually made of copper) in which the fire is placed. The outside is of iron, separated from the copper fire-box by a space of about 3 inches all round for water

Fire-box door, the door opening into the fire-box, facing the locomotive tender, by which coke is supplied to the fire

Fire-box partition: in large fire-boxes a division is made in the box, into which water is admitted: this division is about the height of the fire-box door, and divides the fire into two parts in a locomotive engine, thereby increasing the heating surface of the fire-box

Fire-box stays, in a locomotive engine, deep strong iron stays bolted to the top of the copper fire-box, to enable it to resist the pressure of the steam: round copper or iron stays are also used to connect the outside shell to the inside box, in the proportion of about one stay to every 4 square inches of flat surface

Fire-brick or *Fire-bricks* are used for

lining furnaces, and for all kinds of brick-work exposed to intense heat which would melt common bricks. They are made from a natural compound of silica and alumina, which, when free from lime and other fluxes, is infusible under the greatest heat to which it can be subjected. Oxide of iron, however, which is present in most clays, renders the clay fusible when the silica and alumina are nearly in equal proportions, and those fire-clays are the best in which the silica is greatly in excess over the alumina. When the alumina is in excess, broken crucibles, glass-house pots, and old fire-bricks, ground to powder, are substituted for the common silicious sand used in the ordinary processes of brick-making, but which, in this case, would be injurious, as having a tendency to render the clay fusible.

Fire-clay being an expensive article, it is usual, when making fire-bricks at a distance from mines, to mix with it burnt clay, for the sake of economizing the clay and diminishing its contraction. Mr. Pellatt states that Stourbridge clay, when carefully picked, ground, and sifted, will bear, for brick-making, two proportions (by weight) of burnt clay to one of native clay.

The following Table shows the constituents of several infusible clays:

Authority . .	Dr. Ure.	Vauquelin.	Wrightson.
Description.	Kaolin, or porcelain clay.	Plastic clay of forge les eaux.	Sagger clay, from the Staffordshire potteries.
Silica . . .	52	63	54·38
Alumina . .	47	16	26·55
Iron	0·33	8	8·38
Lime . . .	—	1	—
Carbonic acid .	—	—	3·14
Water . . .	—	10	7·28
	99·33	98	99·73
Remarks . .		Used for making glass-house pots and pottery.	Used for making saggars and fire-bricks.

Fire-clay is found throughout the coal formation, but that of Stourbridge is considered the best. The fire-clays of Newcastle and Glasgow are also much esteemed. Fire-bricks are brought to London from Stourbridge and from Wales; the latter, however, will not stand such intense heat as the Stourbridge bricks.

Fire-bricks are also made at the village of Hedgerly, near Windsor, of the sandy loam known by the name of Windsor loam, and these are much used in London for fire-work, and also by chemists for luting their furnaces, and for similar purposes.

The relative merits of Windsor, Welsh, and Stourbridge fire-bricks are best shown by their value in the market.

The following prices are from the 'Contractor's Pocket-Book for 1850.' They include carriage to London and delivery on the works:

Fire-bricks per M.	£.	s.	d.
Windsor . . .	5	8	0
Welsh . . .	8	12	0
Stourbridge . .	11	6	[illegible]

Fire-bricks. The parts of furnaces exposed to heat are built of bricks made of a description of clay which is to different extents infusible, the qualities chosen for use being regulated by the degree of heat to which they are to be exposed. They are known in commerce by the names of Bristol, Stourbridge, Newcastle, Welsh, and Windsor bricks. The first of these are composed almost entirely of silex, and are infusible at the greatest heat of the blast-furnace; but they are very costly, and seldom used. The second quality are made from clay found in the neighbourhood of Stourbridge, lying in a stratum of considerable thickness between the upper soil and the coal formations: they are used in the construction of furnaces required to resist great heat, such as those for smelting iron ores, glass-making, &c., and sometimes for the linings of retort ovens: for this latter purpose they are considered too expensive, except for the arch immediately over the furnace, as the heat is not intense. The third variety are composed of the clay lying above the coal measures in Northumberland, and for the construction of retort furnaces and ovens are the most desirable.

Fire-damp, in coal mines, is impure carburetted hydrogen

Fire-place, a space within a chimney-piece for the burning of fuel to warm the temperature of the air, and in communication with a shaft or chimney-flue

Fire-tubes, or tube-flues, are those through which the fire passes, for obtaining a large heating surface, fixed longitudinally in the middle compartment of a locomotive engine, between the fire-box and smoke-box

Fires of the Ancients. Palladio says, —"Finding that this subject about fires of the ancients had not been treated of distinctly by any body, I resolved to compose something about it. We are ignorant of most things delivered thereupon by the ancients which might give us some light upon the matter: we must have recourse to the inventions of later times, thereby gradually to obtain a more ample knowledge of it. The Romans were sensible that a continual flame and a great heat from live coals were hurtful to the eyes; they therefore went very wisely about finding out a remedy. They found how dangerous it was to carry fire about the house from one room to another. Stoves are an abominable invention: they cause a continual stench, swell the head, and make men drowsy, dull, and lazy. Most people that use them grow tender and weak: some cannot stir out of those rooms all the winter. The ancients used to light their fire in a small furnace under the earth. Thence they conveyed a great many tubes of different sizes into all the different stories and rooms of the house, which tubes or pipes were invisible, but laid in the thickness of the walls and ceilings, just like water-pipes. Each of these opened at that part of the furnace which joined to the very wall of the house, and through these ascended the heat, which was let in whenever they had a mind it should, whether in dining-rooms, bed-chambers, or closets, much in the manner as we see the heat or steam of water contained in an alembic to ascend and warm the parts most distant from the fire-place. The heat in that manner used to spread so equally that it warmed the whole house alike. It is not so with chimneys or hearths; for if you stand near, you are scorched; if at any distance, you are frozen; but here a very mild warm air spreads all around, according as the fire that warms the pipes laid along the wall opposite to the hearth is more or less burning. Those pipes which dispensed the heat did not open into the very furnace, on purpose

that neither smoke nor flame should get into them, but only a warm steam should enter, which they let out again; thereby creating a continual moderate heat. The fire needed not to be large, provided it was continual, to supply those confined and enclosed pipes with a sufficient power of warming. They dressed their meat at the mouth of the furnace; and all along the walls were disposed kettles, or other vessels, filled with hot water, to keep the meat warm."

Fir-poles, small trunks of fir-trees, from 10 to 16 feet in length; used in rustic buildings and out-houses

Fish, a machine employed to hoist and draw up the flukes of a ship's anchor towards the top of the bow, in order to stow it after it has been catted

Fissure, or *Gulley*, is that crack or split in the strata of the earth which is the receptacle of mineral particles, whose contents are styled a 'lode'

Fistuca, among the Romans, an instrument used for ramming down pavements and threshing-floors, and the foundations of buildings

Fistula, a water-pipe, according to Vitruvius, who distinguishes three modes of conveying water: by leaden pipes, by earthen pipes, and by channels of masonry

Five species of temples (the). There are five species of temples: namely, the pycnostyle, in which the columns are placed far apart; the systyle, in which they are more remote; the diastyle, whose columns are at an ample distance from each other; the araeostyle, in which the intervals between the columns are too great; and the eustyle, whose intercolumniations are justly proportioned. In the pycnostyle species the interval between the columns is equal to one diameter and a half: there is an instance of this in the temple of Julius, and another in the temple of Venus, which is erected in the forum of Cæsar: in all temples of this species the same interval between the columns is observed. In the systyle species there should be an interval between the columns equal to two diameters: this arrangement would leave the space between the plinths of the bases of the columns equal to the extent of the plinths themselves.

Flake white is an English white lead, in the form of scales or plates, sometimes grey on the surface. It takes its name from its figure, is equal or sometimes superior to crems white, and is an oxidized carbonate of lead, not essentially differing from the best of the above. Other white leads seldom equal it in body; and when levigated, it is called 'body-white.'

Flamboyant Style of Architecture, the decorated and very ornamental style of architecture, of French invention and use, and contemporary in France with the Perpendicular style in England. One of the most striking and universal features is the waving arrangements of the tracery of the windows, panels, &c. The foliage used for enrichments is well carved, and has a playful and frequently a good effect.

Flanning, the internal splay of a window-jamb

Flaring, in ship-building, over-hanging, as in the topside forward

Flatting, in house-painting, a mode of painting in oil in which the surface is left, when finished, without gloss. The material is prepared with a mixture of oil of turpentine, which secures the colours, and, when used in the finishing, leaves the paint quite dead.

Flemish bricks are used for paving: seventy-two will pave a square yard: they are of a yellowish colour, and harder than the ordinary bricks

Flemish School of Painting. This school is highly recommended to the lovers of the art by the discovery, or at least the first practice, of painting in oil. It has been

generally attributed to John Van Eyck, who was, it is said, accustomed to varnish his distemper pictures with a composition of oils, which was pleasing on account of the lustre it gave them. In the course of his practice he came to mix his colours with oil, instead of water, which he found rendered them brilliant without the trouble of varnishing. From this and subsequent experiments arose the art of painting in oil; and this wonderful discovery, whether made by Van Eyck or not, soon acquired notice all over Europe. The attention of the Italian painters was soon excited. John of Bruges was the founder of painting as a profession in Flanders. Peter Paul Rubens was the founder of the art.

Float, a flat piece of stone or other material attached to a valve in the feed-pipe of the boiler of a steam engine, and supported upon the surface of the water by a counterweight; used either for showing the height of the water, or regulating the supply from the cistern

Flookan, in Cornish, an earth or clay of a slimy glutinous consistence; in colour, for the most part blue or white, or compounded of both

Floor-hollow, in ship-building, an elliptical mould for the hollow of the floor timbers and lower futtocks

Floors, in early English domestic arrangements, were generally covered with rushes, carpets being seldom used for such purposes even at the close of Elizabeth's reign, although instances occur of tapestry cloths for the feet to rest upon as early as Edward I. It does not, indeed, appear to have been the custom at any time to leave floors bare, whether boarded or paved. Our poets, and particularly Shakespeare, all speak of rushes and other vegetable substances being strewed in the principal apartments.

Floor-timbers, in ship-building, are those placed immediately across the keel, and upon which the bottom of the ship is framed

Floran, an exceedingly small-grained tin, scarcely perceivable in the stone, though perhaps very rich

Florentine lake colour is extracted from the shreds of scarlet cloth: the same may be said also of Chinese lake

Florentine School of Painting. This school is remarkable for greatness; for attitudes seemingly in motion; for a certain dark severity; for an expression of strength by which grace is perhaps excluded; and for a character of design approaching to the gigantic. The productions of this school may be considered as overcharged; but it cannot be denied that they possess an ideal majesty which elevates human nature above mortality. The Tuscan artists, satisfied with commanding the admiration, seem to have considered the art of pleasing as beneath their notice. This school has an indisputable title to the veneration of all the lovers of the arts, as the first in Italy which cultivated them.

Flower-garden (the) "should be an object detached and distinct from the general scenery of the place; and whether large or small, whether varied or formal, it ought to be well protected from hares and smaller animals by an inner fence: within this enclosure rare plants of every description should be encouraged, and a provision made of soil and aspect for every different class. Beds of bog-earth should be prepared for the American plants: the aquatic plants, some of which are peculiarly beautiful, should grow on the surface or near the edges of water. The numerous class of rock-plants should have beds of rugged stone provided for their reception, without the affectation of such stones being the natural production of the soil; but, above all, there should be poles or hoops for those kinds

of creeping plants which spontaneously form themselves into graceful festoons, when encouraged and supported by art."

Flower-garden. There is no ornament of a flower-garden more appropriate than a conservatory or greenhouse, where the flower-garden is not too far from the house; but amongst the refinements of modern luxury may be reckoned that of attaching a greenhouse to some room in the mansion.

Fluccan, in mining, a soft clayey substance, generally found to accompany the cross courses and slides

Fluke, in mining, the head of a charger; an instrument used for cleansing the hole previous to blasting

Flush, a term common to workmen, and applied to surfaces which are on the same plane

Flutings or *Flutes*, the hollows or channels cut perpendicularly in the shafts of columns, &c., in classical architecture: they are used in the Doric, Ionic, Corinthian, and Composite orders

Flux, in metallurgy, saline matters which facilitate the fusion of ores and other substances which are not easily fusible in assays; used also in the reduction of ores

Fly, in mechanics, that part of a machine which, being put in motion, regulates the rest

Fly-wheel, a wheel with a heavy rim, fixed upon the crank-shaft of a land engine, for the purpose of equalizing the motion by the centrifugal force absorbing the surplus force at one part of the action, to distribute it again when the action is deficient

Flyers, stairs that go straight and do not wind, the fore and back part of each stair and the ends respectively being parallel to each other

Focus, among the Romans, an altar, a fire-place or hearth: hence the Latin motto, 'pro aris et focis,'—'for our altars and fire-sides'

Fodina, a mine or quarry

Foge, Cornish, a forge or blowing-house for smelting tin

Foils, foliation; the spaces between the cusps of the featherings of Gothic architecture

Fons, a font, or a natural spring of water, frequently converted into ornamented fountains by the Greeks and the Romans. The latter also erected edifices of various degrees of splendour over natural springs, such as the Grotto of Egeria, near Rome, where the natural cave is converted by the architect into a temple.

Font, the vessel which contains the water for the purposes of baptism. The font is the only relic of our ancient architecture which in its form is at all analogous to the Grecian and Roman vases. The shape which has at different periods been given to it is a subject of some interest. Norman fonts are generally square or circular; the first frequently placed on five legs; but which may be the older form, the square or circle, is not yet known. The circular form continued to be much used during the Early English period; so occasionally was the square. Throughout the continuance of the Decorated style, the octagon was generally used, sometimes the hexagon. During the Perpendicular style, the octagon was almost always used. Until the Reformation, and occasionally after, dipping was practised in this country. Pouring or sprinkling was not unusual previous to the Reformation; for as early as the year 754, pouring, in cases of necessity, was declared by Pope Stephen III. to be lawful; and in the year 1311, the Council of Ravenna declared dipping or sprinkling indifferent: yet dipping appears to have been in this country the more usual mode. The Earl of Warwick, who was born in 1381, was baptized by dipping: so Prince Arthur (eldest son of Henr

VII.), King Edward VI., and Queen Elizabeth, were all baptized in a similar manner.

Font of the time of Edward II.

Foot, an ancient measure of tin, containing two gallons; now a nominal measure, but in weight 60 lbs.; also a lineal measure of twelve inches

Foot-pace, the dais or raised floor at the upper end of an ancient hall

Foot-plate, the platform on which the engine-man and fire-man of a locomotive engine attend to their duties

Foot-stall, the plinth or base of a pillar

Foot-valve, the valve in the passage between the condenser and air-pump of an engine, opening towards the air-pump

Foot-waleing, the plank withinside a ship, below the lower deck

Force of the wind. Air, when in continuous motion in one direction, becomes a very useful agent of machinery, of greater or less energy according to the velocity with which it moves. Were it not for its variability in direction and force, and the consequent fluctuations in its supply, scarcely any more appropriate first mover could generally be wished for; and even with all its irregularity, it is still so useful as to require a separate consideration.

The force with which air strikes against a moving surface, or with which the wind strikes against a quiescent surface, is nearly as the square of the velocity; or, more correctly, the exponent of the velocity varies between 2·03 and 2·05; so that in most practical cases the exponent 2, or that of the square, may be employed without fear of error.

Forceps, tongs used by smiths to take the hot metal from the fire

Force-pumps, the plunger pumps for supplying the boiler of a locomotive engine: the plunger rods are connected to the piston-rods of the steam cylinder

Forcer, in Cornish, a small pump worked by hand, used in sinking small simples, dippas, or pits

Forcing-pump (the) differs but little from a syringe: the latter receives and expels a liquid through the same passage, but the former has a separate pipe for its discharge, and both the receiving and discharging orifices are covered with valves. By this arrangement it is not necessary to remove a pump from the liquid to transfer the contents of its cylinder, as is done with the syringe, but the operation of forcing up water may be continuous, while the instrument is immoveable. A forcing-pump, therefore, is merely a syringe furnished with an induction and eduction valve,—one through which water enters the cylinder, the other by which it escapes from it. The ordinary forcing-pump has two valves: the cylinder is placed above the surface of the water to be raised, and consequently is charged by the pressure of the atmosphere: the machine, therefore, is a compound one, differing from that described, which is purely a forcing-pump, the water entering its cylinder by gravity alone.

Forecastle, a short deck at the fore-part of a ship, above the upper deck, on which castles were for-

merly erected, or places to shelter the men in time of action

Fore-foot, the foremost piece of the keel of a vessel

Fore-ground, the front of a picture

Foreyn, an ancient term to signify a drain or cesspool

Forge, a smith's furnace for heating metals, to render them soft and more malleable

Fork, a short piece of steel which fits into one of the sockets or chucks of a lathe, and is used by wood-turners for carrying round the piece to be turned: it is flattened at the end, like a chisel, but has a projecting centre point, to prevent the wood from moving laterally

Formosity, beauty, fairness, &c.

Form-peys, an ancient term for form-pieces; the lower terminations of mullions which are worked upon sills

Forms and motions of tools. The principles of action of all cutting tools, and of some others, whether guided by hand or by machinery, resolve themselves into the simple condition, that the work is the combined copy of the form of the tool and of the motion employed: thus the geometrical definitions employed convey the primary ideas of lines, superficies, and solids; that is, the line results from the motion of a point, the superficies from the motion of a line, and the solid from the motion of a superficies.

Formula (pl. *Formulæ*), a prescribed rule in arithmetic or mathematics; a maxim: in law, an action, process, or indictment

Formulary, a book containing set forms, rules, or models

Fornax, among the Romans, a kiln for baking pottery

Forum, a large open space used by the Romans for the sale of merchandise, and for public assemblies; also a court of justice

Forum and *Basilica.* The Greeks built their forum with spacious porticoes, two tiers in height, arranged in a square form: the columns of the porticoes were placed at small intervals from each other, supporting stone or marble entablatures; and galleries were made over the lacunaria of the lower porticoes, or places of exercise. In Italy, the mode of constructing the forum was different; because, by a custom sanctioned by its antiquity, the show of gladiators was exhibited there; and therefore the intervals between the columns surrounding the area were greater. The lower porticoes were occupied as the offices of bankers, which situation was calculated to facilitate the management of the public revenue: the upper contained seats for the spectators of the diversions practised in the forum.

Fortification, the science of military architecture; a defensive building

Forward, the fore-part of a ship

Fosses d'aisances: the cesspools of Paris are so called; and they are usually made $3^{m}\cdot00$ long in the clear by $1^{m}\cdot70$, by $1^{m}\cdot50$, to the springing of the semicircular head (9 ft. 10 in. × 5 ft. 7 in. × 4 ft. 11 in. English, nearly): a man-hole, $1^{m}\cdot00$ by $0^{m}\cdot35$ is left for the purposes of emptying and visiting them (3 ft. $3\frac{7}{16}$ × 1 ft. 2 in.) The walls which surround them, as well as the bottom, are exclusively formed of such materials as are most efficacious in preventing the filtration of the matters contained within them. Of late years the usual custom has been to employ the *meulière*, or mill-stone, bedded in mortar composed of lime and cement; the inside being well pointed, and rendered throughout with this mortar. No cesspool is allowed to be used until after an examination, to be certified by the municipal authority. Any infiltration to a neighbour's property gives a title to damages, and the architect and builder are both responsible for ten years to the proprietor, as also to the neighbours, in case any nuisance arises from defects in the execution of the works.

When the cesspools require cleaning, notice is given to the Board of Public Health (aux agents de la salubrité publique), who authorize and direct the operations. In winter these are carried on between 10 P.M. and 7 A. M.; and in summer, between 11 P.M., and 6 A.M. The carts, as well as all the other material of the nightmen, are under the inspection of the above-named officers, and must be, as nearly as possible, both water-tight and air-tight. They contain not more than $2^{m}\cdot00$ cube each, or nearly 71 ft. cube English.

The contents of the cesspools are usually (especially in the modern houses) sufficiently fluid to allow of their extraction by pumps. In this case a small furnace is placed over the bung of the cart, to burn the gas as it rises: the bung itself is plastered over directly the cart is filled. When the contents are too solid to be pumped out, they are conveyed from below in small vessels of wrought iron, called 'tinettes,' holding about 3½ feet ($\frac{1}{10}$th of a mètre cube) each; and the lids are plastered over before the vessels are removed from the cesspool.

Of late years a system of what are called '*fosses mobiles*' has been introduced into the better class of houses. It consists of air-tight tubs, placed in a vault (rendered also as air-tight as possible), which receive the ends of the soil-pipes. These tubs are removed at stated intervals, the openings plastered over, and may in that state be transported at any time of the day. This system obviates the terrible infection of the old kind of cesspool, and is gaining rapidly. Indeed, as the French people are fond of gilt ornaments in their dwellings, and the gases from the cesspools turn them black at once, unless great precautions be observed in covering them, whenever a cesspool is opened, *it is easy to* understand that the '*fosses mobiles*,' which obviate this inconvenience, should become of general use.

Until of late, all the carts were obliged to pass through the Barrière du Combat to deposit their contents at the laystalls of Montfaucon; but some new works have been constructed at Bondy, so as to allow the suppression of this gigantic nuisance at the immediate gates of Paris.

The cleaning of the cesspools of Paris is executed by several private companies, the most important of which is 'La Compagnie Richer,' who do at least one-half of this business: their capital was about £200,000, in land, plant, and buildings. They employ 150 horses and 300 men, of whom 60 are for the repairs of the plant. Their charge is 8f., 9f., and 10f. per metre cube (35½ feet English, nearly), according to the distance.

No cesspool is allowed to be used after being emptied until it has been visited by an 'agent de la salubrité,' to ascertain whether it be water-tight.

The laystalls of Montfaucon consist of two large reservoirs, at a high level, into which the carts are emptied. These reservoirs are about 2½ acres superficial, and apparently 12 feet deep, with a dam between them, to allow of one being used when the other is being emptied. An overflow drain, with sluice-gates at each end, allows the liquid matter to run off to a large basin on a lower level, where it deposits any thing which may be merely in a state of mechanical suspension. On the banks of this reservoir are some important sal-ammoniac works. In the centre is also a sluice-gate, which allows the surplus liquid matters to pass into two smaller reservoirs, where deposition takes place without any interference from the pumping apparatus of the chemical works. From thence the waters pass off into four other basins, in which any

fertilizing properties they may contain are precipitated by means of straw, dead leaves, &c., and the water, comparatively pure, is at length let off into the main sewer, which discharges itself into the Seine, below Paris. The surface of the intermediate basins is about 250m. by 60m. (or 3¾ acres); that of the four last basins is about 350m. by 110m. (or nearly 9½ acres).

These reservoirs do not belong to the city of Paris, and some difficulties have arisen from the proposal to remove them: all the carts containing the night-soil being obliged to discharge at Montfaucon, the farming of the contents of the basins became a source of considerable profit. They were let on the last occasion for a sum of 500,500 francs per annum (£20,020 sterling); the previous letting having been 166,000 francs (£6640 sterling). The increased rent and the exorbitant wages paid during the republican excitement of 1848 proved injurious to the company. The ground occupied by the town, moreover, is not sufficiently extensive for the operations connected with the manipulation of the 'poudrette,' and the company were obliged to rent about 7½ acres more land for the purpose of spreading and drying the compost. The land necessary for this operation had been taken on lease by the outgoing company, and they succeeded in obtaining a sum of £60,000 for the remainder of their term, as no other land was to be had in the neighbourhood.

The rent and labour in conversion costs the company from £12,000 to £16,000 per annum. The 'poudrette' is sold to agriculturists at 8 francs le setier, a measure equal to 12 bushels English.

In one plan adopted for emptying the cesspools, the carts are made of strong boiler plate; they are placed under an air-pump, and exhausted; the pipes are connected with the carts and the cesspools, and the atmospheric pressure on the latter forces up the liquid contents.

Investigations have been made respecting the general health of the workmen employed at Montfaucon, the reservoir of all the excrementitious matter of a city which contains about 1,000,000 inhabitants, and it has been ascertained, that although they were not affected by the cholera in 1849, they are very short-lived men: acute fevers, and gangrene on the slightest accident, carry them off in a frightful manner. Unfortunately the dwellers in the neighbourhood also are subject to the same action, and the mortality from these causes is very great.

The action of the 'poudrette' upon agriculture is somewhat extraordinary. In the time of Henri Quatre, the wines of Suresnes were highly esteemed: the vines produced little, but of a superior quality: since the poudrette has been used to force them, the quantity of their produce has been increased, but the quality has totally changed: from a superior rank, the wines of the neighbourhood of Paris have fallen to that of what is vulgarly called 'du petit bleu.'

Fossil, a mineral, many kinds of which are peculiarly and elegantly shaped

Fossiliferous, a geological term applied to a district abounding in fossils

Foundations, according to Palladio, ought to be twice as thick as the walls to be raised upon them, so that both the quality of the earth and the greatness of the building are to be regarded, making the foundations larger in a soft and loose ground, or where there is a great weight to be supported. The plane of the trench must be as level as possible, so that the weight may press equally, and not incline more on one side than the other, which occasions the cleaving of the walls.

For this reason the ancients were accustomed to pave the plane with Tivertine; but we most commonly lay planks or beams to build on. The foundations ought to be made sloping, that is to say, to diminish as they rise; but yet in such a manner that the middle of the wall above may fall plumb with the middle of the lowest part; which must be also observed in the diminution of walls above ground, because by that means the building becomes much stronger than by making the diminution any other way.

Sometimes, to avoid charges, (especially in marshy grounds, where there is a necessity to use piles,) foundations are arched like a bridge, and the walls are built upon those arches. In great buildings it is very proper to make vents through the body of the walls from the foundations to the roof, because they let forth the winds and other vapours, which are very prejudicial to buildings: they lessen the charges, and are of no small convenience, especially when there is occasion for winding-stairs from the bottom to the top. If it be necessary to construct vaults below ground, their foundations must be more substantial than the walls of the buildings which are to be raised upon them. The walls, pillars, and columns of the latter must be placed immediately over those below them, so that solid may bear upon solid; for if walls or columns project beyond the substructure, their duration must necessarily be short.

The value of concrete in foundations was rendered obvious in a building erected by Mr. Clegg at Fulham, in 1829. The foundation was a quicksand. After the excavation was got out to the depth of 15 feet, an iron rod sunk, with little more than its own weight, 15 feet more; it was, in fact, as *bad a foundation* as could possibly occur. In about twelve days after it was built, it had settled bodily down 16½ inches, without a crack, or deviating in the least from the plumb. It therefore follows, that the only disadvantage attending a bad natural foundation is the expense of making an artificial one. The following extract relates to the erection of an extensive building upon bad ground.

"The building for the Albion Mills was erected upon a very soft soil, consisting of the 'made ground' at the abutment of Blackfriars' Bridge: to avoid the danger of settlement in the walls, or the necessity of going to a very unusual depth with the foundations, Mr. Rennie adopted the plan of forming inverted arches upon the ground over the whole space upon which the building was to stand, and for the bottom of the dock. For this purpose the ground upon which all the several walls were to be erected was rendered as solid as is usual for building by driving piles where necessary, and then several courses of large flat stones were laid to form the foundations of the several walls; but to prevent any chance of these foundations being pressed down in case of the soft earth yielding to the incumbent weight, strong inverted arches were built upon the ground between the foundation courses of all the walls, so as to cover the whole surface included between the walls; and the abutments or springings of the inverted arches being built solid into the lower courses of the foundations, they could not sink unless all the ground beneath the arches had yielded to compression, as well as the ground immediately beneath the foundation of the walls. By this method the foundations of all the walls were joined together so as to form one immense base, which would have been very capable of bearing the required weight, even if the ground had been of the consistency

of mud; for the whole building would have floated upon it as a ship floats in water; and whatever sinking might have taken place, would have affected the whole building equally, so as to have avoided any partial depressions or derangement of the walls; but the ground being made tolerably hard, in addition to this expedient of augmenting the bases by inverted arches, the building stood quite firm."

When the foundation has been properly disposed of, the brickwork may be commenced. The bricks should be well burned, and set with a thin joint, four courses not occupying more depth than 11¾ inches.

Foundations of Temples. In preparing foundations for works of this kind, it will be first necessary to dig down to a regular stratum, if such is to be met with; and upon this the foundations, constructed with great attention to their strength, are to be laid: their solidity must be proportioned to the magnitude of the building in contemplation. The piers above ground, below the columns, should be thicker than the diameter of the columns they are to support by one-half, that these substructures, which are called stereobatæ, on account of their sustaining the whole weight, may be enabled by their greater solidity to support what is built upon them. The bases of the columns, when fixed, ought not to project before the face of the stereobatæ on either side. The intervals between the piers should either be made solid by means of piles, or arched over, so as to connect the piers.

If no compact stratum is to be found, but the ground, on the contrary, is loose or marshy to a great depth, trenches must be dug, and piles of charred alder, olive, or oak, placed close together, be driven in by means of machines: the intervals between them should be filled up with charred timber, and upon this substratum the foundations should be formed with solid masonry. The foundations being reared to the same level all around, the stylobate is next to be constructed. Upon this the columns are to be arranged, in the manner already described, at intervals which are determined by the species of temple intended to be built, whether pycnostyle, systyle, diastyle, or eustyle. In the aræostyle species the columns may be placed at any distance asunder.

Foundations of a Bridge: these consist, properly, of the underground work of the piers and abutments, which it is within the province of a civil engineer to construct: the necessity of firmness and solidity in the execution of such works will be deemed of importance just in proportion to the intended extent and magnificence of the structure they are designed to support

Foundry, a place where masses of metal are melted and run into moulds, so as to assume the required form

Four-way-cock, a cock having two separate passages in the plug, and communicating with four pipes

Fox-tail wedging, in carpentry. This is done by sticking into the point of a wooden bolt a thin wedge of hard wood, which, when the bolt reaches the bottom of the hole, splits, expands, and secures it.

Frame, the strong frame-work, outside the wheels, which supports the boiler and machinery on the axles of a locomotive engine

Frame, inside, in locomotive engines. Some engines have the supporting frames within the wheels, and are called *inside-framed engines*. Besides this frame, resting on the axles, there are also other strong stays from the fire-box to the smoke-box, called *inside framing* or *stays*, for supporting the works and strengthening the boiler.

Frames, the bends of timbers that are bolted together: in small ships there

are two bolts in every shift of timber, and three in large ships. The bolts should be disposed clear of the chain and preventer-bolts, scupper, lodging knee-bolts, and port cells.

Frankfort-black is said to be made of the lees of wine from which the tartar has been washed, by burning in the manner of ivory-black. Fine Frankfort-black, though almost confined to copper-plate printing, is one of the best black pigments we possess, being of a fine neutral colour, next in intensity to lamp-black, and more powerful than that of ivory.

Frater-house, the refectory or hall of a monastic establishment

Fredstole, a seat near the altar

Freedom, in drawing, is a bold and spirited manner, with evident liberty of the pencil; *i. e.* where the drawing is apparently accomplished with ease

Freemason, as applied to ancient architecture: a person learned in the art of building, more particularly in ecclesiastical construction, and who, by his learning in the science and his taste in constructions of edifices, travelled from one country to another, and executed models of everlasting renown. The term may also be applied to a free-stone mason, or a cutter and worker in stone, without reference to the society called Freemasons.

Free-stone, building stone which may be easily cut into blocks and worked with a chisel; so called from having no grain: it may therefore be cut in any direction

Free-stuff, that timber or stuff which is quite clean or without knots, and works easily, without tearing

French chalk is an indurated magnesian mineral, employed to remove grease stains

French School of Painting. This school has been so different under different masters, that it is difficult to characterize it. Some of its artists have been formed on the Florentine and Lombard styles, others on the Roman, others on the Venetian, and a few of them have distinguished themselves by a style which may be called their own. In speaking in general terms of this school, it appears to have no peculiar character, and can only be distinguished by its aptitude to imitate easily any impressions; and it may be added, speaking still in general terms, that it unites in a moderate degree the different parts of the art, without excelling in any one of them.

Fresco, a kind of painting performed on fresh plaster, or on a wall covered with mortar not quite dry, and with water colours. The plaster is only to be laid on as the painting proceeds, no more being done at once than the painter can despatch in a day. The colours, being prepared with water, and applied over plaster quite fresh, become incorporated with the plaster, and retain their beauty for a great length of time. The Romans cut out plaster paintings on brick walls at Sparta, packed them up in wooden cases, and transported them to Rome.

Fret, an ornament used in classical architecture, formed by small fillets intersecting each other at right angles

Friars (the orders of) in England and Wales, previous to their abolition, including the Nuns Minoresses, amounted to—

Black or Dominican friars .	54
Grey or Franciscan friars .	62
Minoresses or nuns of the order of St. Clare . . .	4
Friars of the order of the Holy Trinity for the redemption of captives . .	12
Order of the Carmelites or White friars	50
Crutched or Crossed friars	10
Austin friars	32
Friars de pœnitentia or of the sac	9
Bethlemite friars . . .	6

Friction, the act of rubbing two bodies

together, or the resistance in machines, caused by the contact of different moving parts. Friction is proportional to the pressure; that is, every thing remaining the same, the friction increases as the pressure increases.

Friction-clutch, a shell or box fixed on the end of a driving shaft, fitted by a conical piece which slides on a feather, or raised part, at the end of another shaft, so that it can be engaged at pleasure by the cone being forced into the shell by a lever or screw. This apparatus is very useful for driving machines, the parts of which are subjected to violent strains, as the pressure upon the clutch can be regulated so as to allow it to slide when the strain is too great to be borne safely by the machine.

Frieze, the middle division of an entablature, that which lies between the architrave and the cornice

Frigidarium, the cold bathing-room in the baths of the ancients, as well as the vessel in which the cold water was received

Frigidarium, the cold bath: the reservoir of cold water in the hypocaustum, or stove-room, was termed ahenum frigidarium

Frithstool or *Freedstool*, a seat or chair near the altar, for those especially who sought the privilege of sanctuary

Frontal or *Fronter*, the hanging with which the front of an altar was formerly covered

Fronton, a French word to express an ornament over a door or pediment

Frowy stuff, short or brittle and soft timber

Fucus, a name given by the Romans to certain false dyes and paints

Fuel, the matter or aliment of fire

Fulcrum, the prop or support by which a lever is sustained

Fullers'-earth, a soft unctuous marl, used by fullers in the process of cleansing cloth, &c.

Fulling-mill, an engine, or mill, in which cloth is cleansed by being beaten with hammers

Fulminating gold or *silver*, in chemistry, ammonia combined with the oxides of gold or silver

Fumarium, a chimney; an upper room used among the Romans for collecting the smoke from the lower apartments: used also for smoking or ripening wines

Furling, in navigation, the wrapping up and binding of any sail close to the yard

Furlong, a measure of length; the eighth part of a mile

Furnace. The furnace is one of the most important parts of the high-pressure engine. The whole action and power of the machine depend on its construction, and on the effect obtained from it, inasmuch as fire is the prime agent. Too much industry, exactitude, and intimate knowledge of the subject, cannot be brought to bear on the construction of the furnace, in order to attain the two great objects of its action; namely, first, to produce as perfect a combustion of the fuel as possible; and secondly, to apply as much as possible of the heat so developed effectively to the boiler. These two requirements for a good furnace are, however, not so easily satisfied. Much remains to be acquired as to the conditions under which the whole of the caloric may be perfectly developed from the fuel, although the best manner of applying the heat to the boiler is well understood.

Furniture: anterior to the Tudor age, household furniture was in general of a rude, substantial character; the tables were formed of boards or trestles, the seats of massive oak benches or stools, and the floors strewed with straw

Furniture of the hall: this consisted of but few articles, such as clumsy oak tables covered with carpet, benches or joined forms of the same material, and cupboards for plate, pewter, 'treene,' leather jugs, glass,

&c., with a reredos or fire-iron in the centre of the floor, against which fagots were piled and burned, the smoke passing through an aperture in the roof; the fender, formed by a raised rim of stone or tile, and a 'fier forke' and tongs

Furrings, slips of timber nailed to joists or rafters, in order to bring them to a level, and to range them into a straight surface, when the timbers are sagged, either by casting, or by a set which they have obtained by their weight in the course of time

Fusarole, in architecture, a moulding or ornament placed immediately under the echinus in the Doric, Ionic, and Composite capitals; the shaft of a column, pilaster or pillar, or that part comprehended between the shaft and the capital

Fustic, a wood of a species of mulberry growing in most parts of South America, the United States, and the West Indies: it is a large and handsome tree, principally used for dyeing greens and yellows, and also in mosaic cabinet-work and turnery

Futtock, in ship-building. Every single timber is called a futtock, and distinguished by the terms lower, or first, second, third, &c., except the floors, long and half-timbers, top timbers, stern timbers, &c.

Futtocks, the lower timbers raised over the keel, and which hold the ship together

Futtock shrouds, in ship rigging, small shrouds that go from the main-mast, fore-mast, and mizen-mast shrouds to those of the top-mast

Gable, the upright triangular end of a house, from the cornice or eaves to the top of the building, sometimes called a sloped roof; the upper part of a wall, above the level of the eaves. Examples in English and foreign Domestic and Gothic architecture are various, and generally have a most picturesque effect.

Gablets, small ornamental gables or canopies formed over tabernacles, niches, &c.

Gaff, a sort of boom used in small ships to extend the upper edge of the mizen, and employed for the same purpose on those sails whose foremost edges are joined to the masts by hoops or lacings, and which are usually extended by a boom below: such are the main-sails of sloops, brigs, and schooners

Gage or *Gauge*, an instrument used for measuring the state of rarefaction in the air-pump, variations in the barometer, &c.; a measure, a standard

Gal, in Cornish, rusty iron ore

Galilee, a porch or chapel at the entrance of a church. The galilee at Lincoln cathedral is a porch on the west side of the south transept: at Ely cathedral it is a porch at the west end of the nave: at Durham it is a large chapel at the west end of the nave, which was built for the use of the women, who were not allowed to advance further into the church than the second pillar of the nave.

Gallery, an apartment generally of greater length in proportion to the width, applied for the purpose of exhibiting pictures or sculpture: used formerly in early English Domestic architecture, in large houses, as a place of resort for dancing and other amusements

Galliot, a Dutch vessel, carrying a main and a mizen mast, and a large gaff main-sail

Gall-stone (colour), an animal calculus formed in the gall-bladder, principally of oxen. This concretion varies a little in colour, but is in general of a beautiful golden yellow, more powerful than gamboge, and is highly reputed as a water colour: nevertheless, its colour is soon changed and destroyed

by strong light, though not subject to alteration by impure air.

Galvanism comprises all those electrical phenomena arising from the chemical agency of certain metals with different fluids

Galvanometer, an instrument contrived to measure minute quantities of electricity

Gamboge, or, as it is variously written, *Gumboge*, *Gambouge*, *Cambogia*, *Gambadium*, &c., is brought from Cambaja, in India, and is the produce of several kinds of trees. It is, however, principally obtained from the tree called Gokathu, which grows in Ceylon and Siam. From the wounded leaves and young shoots the gamboge is collected in a liquid state, and dried. Gamboge is a concrete vegetable substance, of a gum-resinous nature, and beautiful yellow colour, bright and transparent, but not of a great depth. When properly used, it is more durable than generally reputed, both in water and oil, and conduces, when mixed with other colours, to their stability and durability, by means of its gum and resin. It is deepened in some degree by ammoniacal and impure air, and somewhat weakened, but not easily discoloured, by the action of light.

Gammoning, in navigation, seven or eight turns of a rope passed over the bowsprit, and through a large hole in the stem or knee of the head, alternately, and serving to bind the inner quarter of the bowsprit close down to the ship's stem, in order to enable it the better to support the stays of the fore-mast: after all the turns are drawn as firm as possible, the opposite ones are braced together under the bowsprit by a frapping

Gammoning-hole, a hole cut through the knee of the head, and sometimes one under the standard in the head, for the use of gammoning the bowsprit

Garboard strake, the strake in the bottom that is wrought into the rabbet of the keel of a ship

Gardens. The ancient plans of gardens show that the Egyptians were not less fond than our ancestors of mathematical figures, of straight walks, architectural decorations, and vegetable avenues; and that they as thoroughly entered into the idea of seclusion and safety suggested by enclosures within enclosures. It has been remarked, that in some old English places there were almost as many walled compartments without as apartments within doors: the same may be said of Egyptian country houses. This principle of seclusion, and an excessive love of uniform arrangement, are remarkably displayed in the plan of a large square garden given in Professor Rosellini's great work.

As a subject for the painter, the materials which form the scenery of a garden are provided by Nature herself: the artist must therefore be satisfied with the degree of expression which she has bestowed, and give the best possible disposition to those scanty and intractable materials. In a landscape, on the contrary, the painter has the choice of the objects he intends to represent, and can give whatever force or extent he pleases to the expression he wishes to convey, as the whole range of scenery is before his eye.

Gargoyle or *Gurgoyle*, a projecting spout used in Gothic architecture, to throw the water from the gutter of a building off the wall

Garland, an ornamental band used in Gothic work

Garnet, a hinge, now called a 'cross garnet;' a red gem of various sizes

Garret, an upper apartment of a house, immediately under the roof

Garretting, small splinters of stone inserted in the joints of coarse masonry: they are stuck in after the work is built: flint walls are very frequently garretted

Gas. All substances, whether animal, vegetable, or mineral, consisting of carbon, hydrogen, and oxygen, when exposed to a red heat, produce various inflammable elastic fluids capable of furnishing artificial light. The evolution of this elastic fluid may be perceived during the combustion of coal in a common fire. The coal, when heated to a certain degree, swells and kindles, and frequently emits remarkably bright streams of flame, and after a certain period these appearances cease, and the coal glows with a red light.

The flame produced from coal, oil, wax, tallow, or other bodies which are composed of carbon and hydrogen, proceeds from the production of carburetted hydrogen gas, evolved from the combustible body when in an ignited state.

If coal, instead of being burnt in the ordinary way, be submitted to the temperature of ignition in close vessels, all its immediate constituent parts may be collected: the bituminous part is distilled over, in the form of coal-tar, &c., and a large quantity of an aqueous fluid is disengaged at the same time, mixed with a portion of essential oil and various ammoniacal salts. A large quantity of carburetted hydrogen, carbonic oxide, carbonic acid, and sulphuretted hydrogen, also make their appearance, together with small quantities of cyanogen, nitrogen, and free hydrogen, and the fixed base of the coal alone remains behind in the distillatory apparatus, in the form of a carbonaceous substance called *coke.* An analysis of the coal is effected by the process of destructive distillation; and the products which the coal furnishes may be separately collected in different vessels.

The carburetted hydrogen, or coal-gas, when freed from the obnoxious foreign gases, may be propelled in streams out of small *apertures,* which, when lighted, form jets of flame, now called *gas-lights.*

Mr. Croll has patented an invention for the purification of gas from ammonia, which is effected by means of dilute sulphuric acid applied between the condensers and the ordinary lime purifiers. The vessels are made either of wood or iron, and lined with lead, having a wash-plate similar to the wet-lime purifiers. The radiating bottom is formed of wooden bars, for the purpose of supporting the wash-plate and distributing the gas. In commencing the process, these vessels are charged with water and sulphuric acid in the proportion of 7 lbs. of the latter to 100 gallons of the former. As the acid is neutralized by the ammonia contained in the gas passing through the vessels, the above proportion is kept up by a continuous dropping or running of acid, regulated according to the quantity of ammonia contained in the gas, from a reservoir placed on the top of the saturator. This mode of supplying the acid is continued until the specific gravity of the solution is at 1170, or near the point of crystallization; after which the supply of acid is discontinued, and the liquor retained in the vessel until neutralized: it is then drawn off and evaporated, and yields a pure sulphate of ammonia.

Gas (distribution of, through mains). There is no branch of science connected with the subject of gas engineering so highly important as that which relates to its conveyance and distribution through pipes; there is none in which theory affords more assistance, and there is hardly any branch to which so little attention has been paid. The interests of a gas company are not best served by simply increasing the quantity of gas from the same quantity of coal, or improving the lime machinery, &c. The laying of street-mains forms the most considerable item in the outlay; and by

a judicious arrangement in the first instance, much may be saved both at first and last.

It is for the purpose of rendering this branch of the science, and that of the passage of gas through pipes, perfectly plain, that the following observations are here given.

When it is proposed to light any town, or district of a town, with gas, the first step to be taken is to ascertain the number of lights, both public and private, that will be required, with as much accuracy as circumstances will permit; the length of time such lights will have to burn, and the quantity of gas consumed by them per hour, making allowances for the increase of lamps that will probably be required by the extension of the town. The size of the works themselves may be easily ascertained from this calculation. It will then remain to fix upon a proper situation in which to erect them: the best local position is upon the banks of a navigable river or canal, and at the lowest available level, and the nearest approach to such a situation is advisable for obvious reasons. A map of the town must be obtained, or a survey made of the different streets and thoroughfares: running levels must be taken through them at several points, and their respective heights marked with reference to the level of the works as a datum: upon this map all the mains must be drawn, also their branches, valves, and governors. Their arrangement must be such as to allow of a perfect circulation of the gas, and a nearly uniform pressure at the highest and lowest point. All the pipes upon the same level should be joined into one another, and no valves used but such as are necessary to shut off the gas for repair of mains. To supply a higher level, a governor should be placed at the summit of the lower level, with the lower main leading into it. The pipe or pipes for supplying the higher parts should proceed from the regulating vessel. A cellar may be appropriated for the reception of this vessel. One leading main should be taken direct from the works to an equilibrium cylinder situated at some point from which several streets diverge, and no supply taken from this main until it has reached the cylinder. Branches suitable to the supply of each division of the district should lead from this cylinder. The supply of gas to the cylinder should be so regulated as to cause the gas to flow along the branches at an even pressure of about five-tenths of an inch. If the cylinder be at any considerable distance from the works, a smaller main, with *increased* pressure, may lead *to* it, its size being sufficient to equalize the discharge.

Supposing a district to be lighted requiring 1000 public or street lamps, and 7000 private burners: it is usually considered that each lamp on an average will consume 5 cubic feet of gas per hour, therefore 40,000 cubic feet will be required to light the district for an hour; and the leading main must be capable of delivering that quantity into the equilibrium cylinder in that time. To determine the size of this main, the probable increase of lamps must be taken into consideration; and as that will depend so much upon circumstances in every instance, the judgment of the engineer alone can serve to regulate the additional area. If the increase should be beyond that which was expected, the gas must be forced through the leading main at a greater pressure.

In the above example, if the diameter of main for a *present* consumption be 12 inches, and to secure an adequate supply at any future period its diameter be increased to 15 inches, the *present* working pressure may be reduced to 1·5 of an inch instead of 3 inches;

and as the leakage will also be decreased, the extra-sized main will not be found disadvantageous even in the first instance.

Gasometer, a reservoir of gas, with conveniences for measuring its volume. The simplest and most general in use consists of an iron vessel, open at the bottom, and inverted into a tank of water below the surface of the ground, having perfect freedom to rise and fall, and guided by upright rods fixed at several points in the circumference. The diameters and numbers of the vessels will vary according to the magnitude of the works to which the gasometer is attached, and the space to be occupied by it. If the works are situated in a town, where the ground is too valuable to allow an increased extent, a 'telescope gasometer' is employed.

Gas-tar, commonly called *coal-tar*. When the manufacture of gas from coal was in its infancy, great advantages were expected to be derived from the coal-tar which distilled over with the inflammable gas. It was considered to be a substance possessing even superior properties to the vegetable tar for the preservation of timber and other perishable materials exposed to the influences of the weather.

In the year 1665 a German chemist proposed to distil coal for the sole purpose of obtaining this tar, and in 1781 the Earl of Dundonald took out a patent for collecting the tar which appeared during the formation of coke. Neither scheme answered. After a few years' trial, coal-tar as a substitute for vegetable tar fell into disuse. It was tried in the navy, and was found to give the timber a considerable degree of hardness, but not of durability. Its smell is extremely offensive; and since that time it has been used only in places where that is of little consequence. The exposed part of the machinery of a gas establishment may be protected by being coated with coal-tar.

Gasket, plaited cord fastened to the sail-yards of a ship, and used to furl or tie up a sail firmly to the yard, by wrapping it round both six or seven times, the turns being at a competent distance from each other

Gatchers, the after-leavings of tin

Gate-house, or park entrance, a structure designed rather to produce an agreeable and picturesque effect, than to accord with any fixed rules or customs of art: such, indeed, was the practice towards the latter end of the sixteenth century, when it would appear, that most men wished to display their taste and learning in architecture. The gate-house also forms an entrance to a private mansion, to any public, municipal, or collegiate building, or to a palace, &c. In the early English architecture, gate-houses, now sometimes called *Lodges*, were large and imposing structures, of great elegance.

Gates and doors are generally, whether arched or square, twice their breadth in height. The former may be ornamented with columns, pilasters, entablatures, pediments, rustics, imposts, archivolts, &c.; the latter with architraves round the sides and top of the opening, and crowned with a frieze and cornice. The cornice in this case is very frequently supported with a console on each side. Columns, pilasters, and other ornaments are also sometimes employed in the decoration of doors.

Inside doors should not be narrower than 2 feet 9 inches, nor is it needful that they exceed 6 feet in height; entrance doors, 3 feet 6 inches to 6 feet 6 inches broad in private dwellings: but in public buildings, where crowds assemble, they must be considerably enlarged. The smallest width for a gate should be 8 feet 6 inches.

As some general rule for the proportion of the architraves of com-

mon dressings to doors may be useful, the following directions may be safely followed: Supposing the height of the aperture to represent the height of a column; then, if an architrave, frieze, and cornice, or the first only, be desired, take them in the proportion that would serve for the order itself, and return the architrave down the sides of the door. The whole entablature over a square-headed door should never exceed one-third the height of such aperture.

Gauge (pronounced *gage*), a measure by which the capacity or contents of a cask or vessel may be ascertained. *Gauging* is a term used in mensuration, and applied by engineers in their several operations. *The gauge*, as applied to railways, became a familiar term during the antagonistic discussions respecting the proper distance between the lines of rail; and the *battle of the gauges*, which raged fiercely and expensively, ended, like many similar contentions, in both parties spending enormous sums of money, without the result of victory on either side.

Gauge, a mixture of fine stuff and plaster, or putty and plaster, or coarse stuff and plaster; used in finishing the best ceilings and for mouldings, and sometimes for setting walls

Gauge-cocks, two or three small cocks fixed in front of the boiler of a steam engine, for the purpose of ascertaining the height of the water

Gauge-glass, in locomotive engines, a strong glass tube, connected with the boiler by two cocks attached to the gauge-cock pedestal. The water is admitted to this tube by the lower cock, the steam by the upper cock. It thus becomes an index to what is going on inside the boiler, exhibiting the height or agitation of the water in it. A small cock is placed below the glass for blowing out any sediment which may be deposited in it.

Gauge-lamp, in locomotive engines, a small lamp placed beside the gauge-glass at night, that the state of the water in the boiler may be seen by the engine-man

Gauntlet, in heraldry, an iron glove: in challenges, the gauntlet was thrown down in defiance

Gear, furniture, dress, harness: the term is also applied to the several working parts of a locomotive steam engine

Generating surface, the heating surface of a boiler, or that on which heat is applied to generate steam

Gentese, in early English architecture, cusps or featherings in the arch of a doorway

Geometry, the science of quantity, extension, or magnitude

Geoscopy, a knowledge of the different kinds of earth

German School of Painting. In early times, a school of painting can hardly be said to have existed in Germany: it was merely a succession of single artists, who derived their manner from different sources of originality and imitation. There were some German painters of eminence when the art, emerging from its barbarous state, first began to be cultivated in Europe; but as they were totally unacquainted with the ancients, and had scarcely access to the works of their contemporaries in Italy, they copied Nature alone, with the exception of somewhat of that stiffness which forms the Gothic manner. This is by no means the case with their successors, some of whom were educated in Flanders, and others in Italy. But if Mengs or Dietrich were comprehended in this school, there would be nothing peculiar to its manner discovered in their works. Albert Durer was the first German who corrected the bad taste of his countrymen: he excelled in engraving as well as in painting; his genius was fertile, his compositions varied, his thoughts ingenious, and his colours brilliant.

His works, though numerous, were finished with great exactness. For an account of this great man and his productions, see the 'Works of Divers Ancient Masters,' in two vols. folio, 1846.

Geology (a treatise or discourse on the earth) "is a term which admits of a very wide interpretation, and naturally suggests to the mind inquiries,—1st, into the formation and original condition of the earth; 2ndly, into the successive modifications which it has undergone, and the agencies by which they have been effected; and 3rdly, into its present condition, and the agencies by which changes in that condition are still effected. The first object of the geologist is to establish, on the principles of inductive reasoning, the science as it depends on each of these inquiries, and then to apply it to the practical purposes of life. It may be premised that a science is practicably valuable just in proportion as its facts have been discovered, and its laws established and studied; for so long as we are uncertain whether a known result has proceeded from a definite cause, we are unable to apply the fact or circumstance to the elucidation of other facts or circumstances; and so long as we are unacquainted with the properties of any substance under our examination, we cannot declare with certainty what share it may have had in the phenomena we have observed. This may be illustrated by a reference to gunpowder. Its explosive quality is the result of its composition, and we can only depend upon the results when we know that the compound has been accurately formed: to insure, therefore, certainty in the operations depending on it, we must take care that a proper standard of composition has been adhered to. In a similar manner we can only apply geology as a practical science when we have ascertained and made ourselves familiar with those facts which prove the first principles on which it has been founded to be correct and stable."

Gib and key, the fixed wedge and the driving wedge for tightening the strap which holds the brasses at the end of a connecting-rod in steam machinery

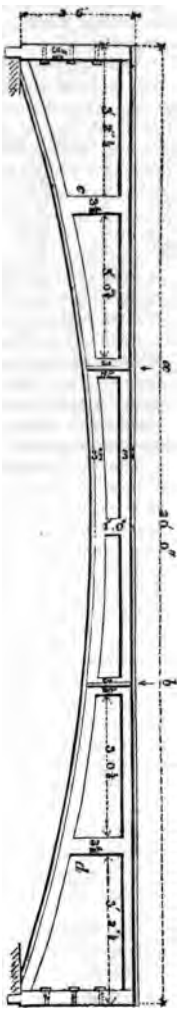
Gimlet, a piece of steel of a cylindrical form, having a transverse handle at the upper end, and at the other, a worm or screw, and a cylindric cavity, called the cup, above the screw, forming, in its transverse section, a crescent. Its use is to bore small holes: the screw draws it forward in the wood, in the act of boring, while it is turned round by the handle: the angle formed by the exterior and interior cylinders cuts the fibres across, and the cup contains the core of wood so cut: the gimlet is turned round by the application of the fingers, on alternate sides of the wooden lever at the top.

Girders, the longitudinal beams in a floor. Girders are the chief support of a framed floor: their depth is often limited by the size of the timber, but not always so; therefore the method of finding the scantling may be divided into more than in one case. Girders of wrought and cast iron are now extensively used for bridges, to girt railroads, canals, &c., many of which are of considerable span: the following will give a better explanation of the importance of testing their strength.

Experiments on an open cast-iron girder.—Figures 1 and 2, in the annexed diagrams, show the elevation and section of a cast-iron open girder, which was intended to act as a bressummer between the columns which supported an iron sheet roof of 40 feet span. These columns were 20 feet apart from centre to centre, and the principals of the roof being 6 feet 8 inches apart, two of them were of course supported

by the iron girder at the points *a* and *b*.

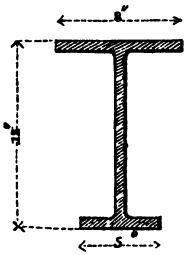
Fig. 1.



The maximum weight thus thrown on the girder, according to a calculation made at the time, would amount to 2½ tons at each of the points where the principal bore upon it; giving a total pressure of 5 tons: this was on the supposition that the weight of the roof itself, and the action of the wind upon it, would prove equivalent to a weight of 40 lbs. on the foot superficial.

The roof was erected by the contractor who furnished the plan, and had undertaken the work at his own risk. When it arrived on the ground, the slightness of the girders was such as to render it advisable to subject them to necessary proof before proceeding to place them in the work. Accordingly, two girders

Fig. 2.



were placed at a short distance apart, and properly fixed; baulks were then laid across from one to the other, at the two points *a* and *b*; and upon these, planks were laid, which carried pigs of iron. They did not show much symptom of weakness until 4 tons were placed on the platform; but with this load, which was less than one-half of what the two should have carried, the two vertical braces, *c* and *d*, were broken by a tendency of the under flange of the girder to rise at those points in a direction perpendicular to the curve, and the whole very soon gave way, and was completely smashed. In this case, not only was the metal too thin, but the connecting pieces between the upper and lower flanges were too slight, and too far apart; the top flange was made wider than the bottom, in order to give a bed for the shoe of the principal: had the openings been filled in, the girder might have stood the test, though even then it would have been but slight.

Fig. 3 shows two links of a chain guy for supporting a pair of shears, erected for lifting heavy weights, such as boilers, &c.: these links were about 6 feet 6 inches long, and were made of 2-inch round iron: they were subjected to the following proof by means of an hydraulic press.

With 35 tons, these two links stretched $\left\{ \frac{1}{10} \right.$ of an inch.

With 40 tons, these two links stretched } $\frac{3}{8}$ of an inch, and had then a permanent set.

With $60\frac{1}{4}$ tons they stretched $3\frac{1}{4}$ inches and broke, the metal being clean and sound. In this case the breaking weight was about double that which might have been fairly placed upon the chain, viz. about 31 tons, which would have been at the rate of 10 tons upon the square inch; for although 35 tons did not apparently cause any set during the time the experiment lasted, yet it is impossible to say that that weight might not have caused such an effect, if left for a sufficient length of time.

Fig. 3.

The following formula is deduced from Mr. Hodgkinson's experiments. "As the distance between the supports in feet is to the depth in feet of the beam in the middle of its length, so is the area in inches of the bottom flange to a fourth quantity, which, when multiplied by a constant number to be determined by experiment, will give the breaking weight in tons."

This given number may be taken at 27·3 for common beams; then half of this quantity will be the weight which the girder will bear, if distributed equally over its length. The ratio of the area of the middle section of the top flange to that of the bottom should be about 1 to 4, or 4·5.

The diagram (fig. 4) represents a girder of 18-feet bearing: the maximum weight which would ever be thrown upon it, including the weight of a fire-proof floor, was considered to amount to about 200 lbs. on the foot, or 14 tons spread over its length: two of these girders were placed at but a short distance apart from each other, and loaded uniformly over their whole surface with iron ballast; a horizontal line was struck upon one of the girders, and the deflection measured when each weight was applied.

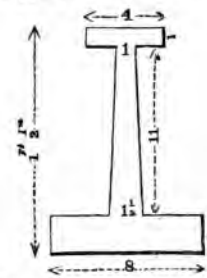
Twenty tons of ballast gave a deflection of $\frac{1}{4}$ inch.

184 . April	Tons.		Tons.	Deflection.
13.	4	added, making	24;	$\frac{1}{8}$.
15.	2	do.	26;	$\frac{3}{8}$.
16.	2	do.	28;	$\frac{3}{8}$.
17.	2	do.	30;	$\frac{3}{8}$.
18.	2	do.	32;	$\frac{3}{8}$.
20.	4	do.	36;	$\frac{9}{16}$.

April 23.—Deflection still the same, the weight having remained undisturbed.

April 29.—No alteration had taken place in the deflection, and the weights being removed, the girder resumed its original form, showing no trace of a set or permanent alteration.

The section annexed shows the relative proportions of the upper and under flanges of the girder: the top and bottom of the girder were parallel, but the lower flange, being 8 inches broad at the middle, diminished to 4 inches at the point of support.



The computed breaking weight, according to Mr. Hodgkinson's rule, would be

$$\frac{16 \times 1{\cdot}166}{18} \times 27{\cdot}3 = 28{\cdot}28 \text{ tons:}$$

half of this, viz. 14 tons, distributed

over the whole length, should be its maximum load; whereas it carried 18 tons, or 36 tons placed on two girders, without showing any symptoms of giving.

The average weight of a large number of these girders amounted to about 16¾ cwt.

Gland, the pressing piece of a stuffing-box of a steam-engine

Glass: this artificial transparent substance was introduced very early. Hollinshed says, an Englishman named Benedict Biscop, who had taken upon him the habit of a monk in Italy, came here with the Archbishop of Rome, in the year 670, and brought painters, glaziers, and other such curious craftsmen into England for the first time.

Glasses superseded small drinking-bowls; they were of Venetian manufacture, and probably first brought here in the 16th century. Earlier they do not appear to have been used in England; nor to have come into much fashion till the time of Elizabeth.

Glass water-gauge. See *Gauge-glass.*

Glazing, the art of affixing glass to the sashes of windows, casements, &c., for the purpose of admitting the light of day; anciently applied to the affixing to windows decorative, stained, and painted glass. A great many beautiful examples exist in this and other countries, of early designs, and of examples in the cinque-cento style: for the latter, see 'Divers Works of Early Masters,' 2 vols. folio, 1846.

Glazing is also a term applied to the finishing of a drawing with some thin, transparent, and glossy tint, through which the first colours appear, and are heightened in their effect

Glebe, turf, soil; land possessed as part of the revenue of an ecclesiastical benefice

Glist, a shining black or brown mineral, of an iron cast

Glue, a tenacious viscid matter, which is used as a cement by carpenters, joiners, &c. Glues are found to differ very much from each other in their consistence, colour, taste, smell, and solubility. Some will dissolve in cold water, by agitation; while others are soluble only at the point of ebullition. The best glue is generally admitted to be transparent, and of a brown yellow colour, without either taste or smell. It is perfectly soluble in water, forming a viscous fluid, which when dry preserves both its tenacity and transparency in every part, and has solidity, colour, and viscidity, in proportion to the age and the strength of the animal from which it is produced. To distinguish good glue from bad, it is necessary to hold it between the eye and the light; and if it appears of a strong dark brown colour, and free from cloudy or black spots, it may be pronounced to be good. The best glue may likewise be known by immersing it in cold water for three or four days, and if it swells powerfully without melting, and afterwards regains its former dimensions and properties by being dried, the article is of the best quality.

A small portion of finely levigated chalk is sometimes added to the common solution of glue in water, to strengthen it and fit it for standing the weather.

A glue that will resist both fire and water may be prepared by mixing a handful of quicklime with four ounces of linseed oil, thoroughly levigated, and then boiled to a good thickness, and kept in the h ade, on tin plates, to dry. It may be rendered fit for use by boiling it over a fire in the ordinary manner.

Glyphs, perpendicular flutings or channels used in the Doric frieze

Gobbets, stones; a measure or quantity, so called in the time of Edward III.

Gola, the Italian term for *cyma*

Gold, a well-known valuable metal

found in many parts of the world, but the greatest quantity of which is obtained from the coast of Guinea. The produce of California remains to be determined. Gold seems to be the most simple of all substances. It is spoken of in Scripture, and the use of it among the ancient Hebrews, in its native and mixed state, and for the same purposes as at present, was very common. The ark of the covenant was overlaid with pure gold; the mercy seat, the vessels and utensils belonging to the tabernacle, and those also of the House of the Lord, as well as the drinking-vessels of Solomon, were formed of this metal.

Gold occurs, in the metallic state, mixed with several metals, but more commonly with silver and copper, and sometimes pure.

Golden sulphur of antimony, golden yellow, is the hydro-sulphuret of antimony, of an orange colour, which is destroyed by the action of strong light. It is a bad dryer in oil, injurious to many colours, and in no respect an eligible pigment either in oil or water.

Gold purple, or *Cassius's purple precipitate*, the compound oxide which is precipitated upon mixing the solutions of gold and tin. It is not a bright, but a rich and powerful colour, of great durability, varying in degrees of transparency, and in hue from deep crimson to a murrey or dark purple: it is principally used in miniature painting, and may well be employed in enamel painting.

Gondola, a Venetian barge much ornamented, used in the canals of Venice for the convenience of the inhabitants: the common dimensions are 30 feet by 4 feet: each end is terminated by a very sharp point, which is raised perpendicularly to the full height of a man

Goniometer, an instrument for measuring angles and crystals

Gorged, in heraldry, the bearing of a crown, coronet, or the like, about the neck of a lion, swan, &c.

Gossan, an imperfect iron ore, commonly of a tender rotten substance, and of a red or rusty iron colour

Gothic Architecture, usually so called. Both Mr. Britton and Mr. Pugin have treated of it by the name of 'Christian Architecture.' It had its rise from the Romanesque: this took its origin from Roman remains at the declension of that empire. It became Saxon, then Norman, and varied in its character with the maturity of years. It was Early English, Perpendicular, Decorated, Flamboyant, &c., till it lost its ecclesiastical and monastic character in the Domestic, which prevailed in the Tudor style (Renaissance), followed by the Elizabethan, &c.

Gouge, in carpentry, an instrument like a round hollow chisel

Governor, the apparatus for regulating the supply of steam to the cylinder so as to give a constant velocity to the engine. It consists of two balls suspended from a vertical spindle, and revolving with it: the suspending rods are connected by arms to a sliding-piece which fits the spindle and acts upon a lever attached to a throttle-valve in the steam-pipe: the balls rise by the centrifugal force as the velocity increases, and close the valve: when the velocity diminishes, the balls fall, and open the valve.

Governor, a contrivance for equalizing the motion of mills and machinery, as well as being used as above described

Governor balls, the solid metal balls fixed on the ends of the suspending rods of the governor

Governor (gas). The governor is a machine for regulating and equalizing the flow of gas from the gasometers to the street-mains, and is much more perfect in its action than any slide-valve applied for that purpose requiring attendance. Its use is no where sufficiently appreciated. Had it been a compli-

cated piece of machinery, or expensive in its first cost and after-application, objections to its adoption would not have been surprising, —but it is perfectly simple, its action is certain and unvarying, and its first cost inconsiderable.

The velocity of gas in the mains and pipes of supply is, in the first instance, as various as there are differences in their altitudes and extent. A main at one place will furnish, with a certain pressure of gas, a flame one inch high; while at a different altitude it will furnish a flame double that height. If, again, in the direction of the main there are many bends, angles, or contractions in its diameter, the velocity of the gas through it will vary considerably more than if it were direct and uniform. If the pipe be of any great length, and of uniform bore, but unequally furnished with branches, the burners will be unequally supplied with gas: those which are near its head will be supplied with a fuller stream of gas than those which are situated towards its termination.

Independently of these differences, arising from diversity of local positions, there will always be one great variation in the velocity of the gas, occasioned by the variety of periods during which lights are required by different consumers supplied from the same main or system of pipes: for example, when a certain number of burners is to be supplied, and it happens that one-half are shut off sooner than the rest, the velocity of the gas in the mains will be materially increased, and the remaining lamps should be turned down; but many would not be reduced, and much gas would be lost.

Gowan, decomposed granite; but the term is sometimes applied to the solid rock

Gozzan, oxide of iron and quartz

Grace is taken for beauty, graceful form or agreeableness of person; for form, friendship, and kindness; for certain gifts of God, which He bestows freely, when, where, and on whom He pleases: such are the gifts of miracles, prophecy, language, &c.

Grace principally consists in the turn that a painter gives to his objects, to render them agreeable,—even those that are inanimate. It is more seldom found in the face than in the manner; for our manner is produced every moment, and can create surprise. A woman can be beautiful but one way, yet she can be graceful a thousand. Grace is neither found in constrained nor in affected manners, but in a certain freedom and ease between two extremes.

Gradation, in painting and drawing, implies the gradual receding of objects into the remote distance, by a proper strength or due diminution of light, shade, and colour, according to their different distances, the quantity of light which shines upon them, and the medium of air through which they are seen

Gradient, a deviation from a level surface to an inclined plane

Graduation, the division of philosophical instruments into degrees and other minute parts

Grain tin, the finest tin, smelted with charcoal; also the ore of very rich tin sometimes found in the form of grains or pebbles

Grange, a monastic farming establishment: in ancient times it was common to attach farm-houses and granaries to the estates of religious institutions

Granite, a natural stone of great strength, hardness, and durability; much used in building: it is a primary and unstratified rock, consisting of quartz, mica, and felspar, each crystallized and cohering, but without any base or cement

Grapnel, in navigation, a sort of small anchor with four or five flukes or claws, commonly used for boats and small vessels

Gravel, a geological term applied to those sabulous soils, or assemblages of worn and rounded stones, which are found scattered on the surface of the earth

Graver, the burin of an engraver; a square piece of steel fixed in a handle, and bevelled diagonally at the end: an instrument used for turning iron, after it has been roughed out by the 'heel tool,' is so called

Gravity is that power or force which causes bodies to approach each other. This universal principle, which pervades the whole system of nature, may be enunciated as follows: the mutual tendency of two bodies towards each other increases in the same proportion as their masses are increased, and the square of their distance is decreased; and it decreases in proportion as their masses are decreased, and as the square of their distance is increased.

Gravity is also the force wherewith a body endeavours to descend towards the centre of the earth: this is called *absolute gravity* when the body tends downwards in free space, and *relative gravity* is the force it endeavours to descend with in a fluid. *Terrestrial gravity* is that force by which bodies are urged towards the centre of the earth, and it is measured by the velocity generated in a second of time. Experiments show that a falling body describes $16\frac{1}{12}$ feet in one second, and it has then acquired a velocity of $32\frac{1}{6}$ feet, which is therefore the true measure of the force of gravity.

Gray colour is the third and last, being the nearest in relation of colour to black. In its common acceptation, gray denotes a class of cool cinerous colours, faint in hue; whence we have blue-grays, olive-grays, green-grays, purple-grays, and grays of all hues, in which blue predominates; but no yellow or red grays, the predominance of *such hues* carrying the compounds into the classes of brown and marrone, of which gray is the natural opposite.

Graywacke, a coarse slate; in geology, a secondary rock

Grease-cock, a short pipe fixed in the cylinder cover of a steam engine, with two stop-cocks inserted at a short distance apart, and a funnel at the top for holding tallow. When the upper cock is opened, the tallow falls into the intermediate space; the cock is then closed, and the lower one opened for the melted grease to enter the cylinder, and lubricate the piston without allowing the steam to escape.

Green verditer is the same in substance as blue verditer, which is converted into green by boiling it

Green ebony wood, imported from the West Indies, is used for round rulers, turnery, marquetry-work, &c.; it is also much used for dyeing, and contains resinous matter

Greenheart wood, from the West Indies, resembles cocoa wood in size and bark, and is used for turnery and other works

Grees, steps; also a staircase

Gregorian Chant: Cantus Gregorianus, Cantus Firmus, Cantus Planus or Plenus, in Latin; Canto Firmo, in Italian; Plein Chant, in French; Plain Chant, in English; and Choral, in German. This species of music is the most ancient of all, and is still the only one properly adapted to the ritual services of the Christian churches.

The Gregorian chant consists of a few notes, on which the words of the Liturgies are recited. The earliest specimens in existence consist of only one or two notes, and were used by St. Ambrose, at Milan, in the fourth century. The origin of this chant is traced to the earlier churches of Egypt, Thebes, Palestine, Arabia, Phœnicia, Syria, &c., from whence it was introduced into the church of Constantinople by St. John Chrysostom. St. Ambrose is said to have brought it into use

in Milan, "after the custom of the inhabitants of the East," and from Milan it came to Rome "long before the time of St. Gregory." But as, in the course of time, various mutations had taken place, St. Gregory, in order to reform and settle the music for the church, made a compilation of such as was fit for its use, and formed the first ritual book of music, or Roman Antiphonarium. From the order which he gave it, and in consequence of this work of Gregory being afterwards established in the other (the Western) churches, it received the name Gregorian. We have very little of the music ascribed to Gregory himself, a specimen of which is given by Mr. Spencer in his work on the church modes, and is very grand. A portion of the old Gregorian chant is still used in our cathedrals in the so-called 'intoning the service' by the minor canons, and also in the responses by the choir, but in a very mutilated form. But in the chanting of the prose Psalms, it is almost entirely abandoned; the only specimen (and that somewhat mutilated) being the grand and well-known 'Tallis's chant.' There is a remarkable difference between the Gregorian melodies for the Psalter and Canticles (and which are called the *eight tones*) and those of a more modern date. No such thing as a double chant exists in Gregorian music, and the 'tones' are formed on one general law; *i. e.* a 'tone' consists of one principal note, called the Dominant, *i. e.* the predominant or reciting note, upon which the principal part of each half-verse is chanted, the remainder being inflected in cadences of one or several notes revolving (as it were) above and below the dominant, or terminating on the final of the mode; and it is a law that the reciting parts are always (when the tone is regular) on the same note, viz. the dominant. There are very few instances of any deviation from this rule. In the modern system there seems to be a total absence of any rule of this sort, and the cadences, both in the middle of the verse and at the end, consist of a greater number of notes, and these of unequal value. Moreover, in the Gregorian chant no attention is paid to time; it is regulated entirely by emphasis and syllabic quantity, not by time and accent, as in modern chanting. On Sundays and the greater festivals it is a rule to commence the 'tone' with a few preliminary notes, called the intonation, which serve as an inchoation, or induction to the dominant, or reciting note: on other occasions, these initial notes are not used. For specimens of the adaptation of these Gregorian tones or chants to the Canticles, &c. of the English church, see the 'Hymnal,' by Mr. Spencer.

Gregorian music requires a nobler and more rigid harmony than can be given in the modern system; and its effects in the divine offices, when properly harmonized and performed, are far superior to any other kind of church music.

Greut, or *Grit*, a kind of fossil body, consisting of sandy, rough, hard, earthy particles

Grey. See *Gray*.

Griddle, a large wire sieve, used instead of a hurdle, for sifting and sorting copper ore as it rises from the mine

Griffin, in heraldry, a fabulous animal, feigned to be between the lion and eagle, and to have the paws and head of the first, with the beak and wings of the last

Grindstone, a cylindrical stone, on which, being turned round its axis, edge-tools are sharpened by applying their edges to the convex surface

Gripe, the lower part of the knee of the head that connects with the foremost end of the keel of a vessel

Grit, coarse sand; rough hard particles of sandstone

Groin, the angle formed by an intersection of vaults: most of the vaulted ceilings of the buildings of the middle ages were groined, and therefore called groined ceilings. During the early part of the Norman style the groins were left purposely plain, but afterwards they were invariably covered with ribs.

Groins, in coast engineering. A groin is a frame of wood-work, constructed across a beach, between high and low water, perpendicular to the general line of it, either to retain the shingle already accumulated, to recover it when lost, or to accumulate more at any particular point; also to break and check the action of the waves.

The component parts of a groin are piles, planking, land-ties, land tie-bars, blocks, tail-piles, and keys and screw-bolts.

The length of a groin depends on the extent, and the requisite strength of its component parts on the nature of the beach on which it is to be constructed.

Those at Eastbourne, on the coast of Sussex, of which the following is more particularly a description, are from 150 to 250 feet in length, and the beach at that place being very rough, consisting of coarse heavy shingle and large boulders, they require to be composed of proportionably strong materials to resist its force.

The piles are from 12 to 25 feet long, and 8 by 6½ inches scantling, shod with iron.

The planking is in lengths of 8, 12, and 16 feet, 2½ inches thick, and with parallel edges.

The land-ties are of rough timber from 20 to 25 feet long, and large enough at the but-end to receive the bars.

The land tie-bars are 13 ft. 6 in. long, and 12 by 5 in. scantling.

The land tie-bar blocks are about 2 feet long, and of the same scantling as the piles.

The land-tie tail-keys are about 2 feet 6 inches long, and 6 by 2½ inches scantling.

The above materials are of oak or beech.

The screw-bolts are of inch round iron, 2 feet 9½ inches and 2 feet 1½ inch long, in equal proportions.

The relative proportions of the component parts are, four piles, one land-tie with tail-piles and keys, one land tie-bar with two blocks, two long and two short bolts, about 180 square feet of planking, and about 140 six-inch spikes for every 16 feet in length; and the expense of a groin, constructed with materials of the above dimensions, may be calculated at about £30 for the same length.

GENERAL RULES OBSERVED IN THE CONSTRUCTION.

When the object, in constructing a groin, is to recover shingle, or accumulate more, the first pile is driven at the high-water mark of neap-tides, leaving its top level with that of spring-tides. The next is driven at the point on the sands, beyond the bottom of the shingle, to which the groin is to extend, leaving about 4 feet of it out of the beach.

The tops of these two piles may be taken for the general slope of the groin, unless the beach should be very steep, and much curved, in which case it becomes necessary to follow its curvature in some degree.

From the high-water mark of neap-tides, the piles are carried back nearly level to that of spring-tides, and as much further as may be considered necessary.

The piles are driven 4 feet asunder from centre to centre, and so as to admit the planking between them alternately, and they should be sunk about two-thirds of their length.

The longest piles are placed between the high-water mark of neap-tides and the bottom of the shingle, particularly from 20 to 40 feet below the former point.

The planking is, if possible, car-

ried down to about two-thirds from the tops of the piles, and kept parallel with them.

The land-ties are placed about one-third from the top of the planking (supposing the latter to commence from the tops of the piles), and their tails are sunk to the level of the bottom of the planking, or as nearly so as possible.

Grotesque. This term, which is now familiar among all the lovers of the art of painting, was by the Italians appropriated to that peculiar manner of composition and invention observed among the antique monumental paintings which were discovered in the subterraneous chambers that had been decorated in the times of the ancient Romans; and as the Italians apply the word Grotto to express every kind of cave or grot, all paintings which were in imitation of the antique designs discovered in those chambers, which for ages had been covered with ruins, are grotesqued or grotesque, which is now applied to English subjects of a quaint and anomalous character.

Grotesque, a name given to the light and fanciful ornaments used formerly to characterize persons and things

Grotto, a natural or artificial cavern or cave

Grouan lode, any tin lode which abounds with rough gravel or sand

Ground-plate or *ground-sill*, the lowest plate of a wooden building for supporting the principal and other posts

Grounds, pieces of wood fixed to walls and partitions, with their surfaces flush with the plaster, to which the facings or finishings are attached

Ground table stones, the projecting course of stones in a wall above the plinth

Ground-ways, large pieces of timber laid across a ship or dock, and upon which the blocks are placed

Grouping is the combining or joining objects in a picture for the satisfaction of the eye, and also for its repose; and although a picture may consist of different groups, yet those groups of objects, managed by the chiaro-oscuro, should all tend to unity, and one only should predominate

Guag, Cornish. Tinners, holeing into a place which has been wrought before, call it holeing in guag

Gudgeon, the iron piers fixed in a beam or wooden shaft for bearings

Gudgeons, in ship-building, are eyes driven into the stern-post, to hang the rudder on

Guide-blocks, pieces of metal with parallel sides, fitted on the ends of a cross-head of a steam engine, to slide in grooves in the side frames, and keep the motion of the piston-rod in a direct line

Guilloche, an ornament used in classical architecture, formed by two or more intertwining bands

Gules, in heraldry, a red colour

Gulph of ore: a lode which throws up very great quantities of ore, and proves lasting and good in depth, is so called

Gum wood, or *blue gum wood*, is the produce of New South Wales, sent over in large logs and planks similar to dark Spanish mahogany: it is used in ship-building, &c.

Gun-metal, a mixed metal, an alloy of copper and tin

Gunnies, in Cornish, a term applied to breadth or width: single gunnies are 3 feet wide

Gunter's chain, the chain in common use for measuring land: the length of the chain is 66 feet, or 22 yards, or 4 poles of 5½ yards each; it is divided into 100 links of 7·92 inches each. *See* Acre.

Gunwale, or *gunnel*, in ship-building, the piece of timber which reaches on either side of the ship from the half-deck to the forecastle

Gunwale, the plank that covers the heads of the timbers between the fore and main drifts

Gussets, as understood in mechanical construction, are brackets or angular pieces of iron, to strengthen, to keep steady, and support a structure.—

In the construction of the rectangular covered openings of the Britannia and Conway iron bridges, gussets are used extensively in the interior, consisting of double triangular plates riveted to the bottom and sides of the plates of the bridge, as a series of brackets (and at the top and either sides also), to add to the strength and durability of these extraordinary works, and as a counter-effort to the tendency of strain on the lower sides to separate or open the joints, and on the upper side to force them closer together.

Gusto, a term used by the Italians, signifying taste in the design of the attitudes, good arrangement, and composition of a picture

Guttæ, ornaments resembling drops, placed in the epistylium of the Doric order below the triglyphs. They occur likewise in the under face of the mutules in the Doric corona. They are supposed to have originated from the intention to represent drops of water running off the roof, adhered to the under surface of the canterii or rafters of early buildings.

Gybing, in navigation, the shifting of any boom-sail from one side of the mast to the other

Gymnasium, a public building used by the Greeks for the practice and exercise of gymnastics, or muscular development; also a place, according to Vitruvius, for amusements and scientific recreation

Gynæceum, in Greek architecture, the apartment of the females in the interior of the house; the nursery

Gypsoplaste, a cast taken in plaster of Paris or white lime

Gypsum, sulphate of lime, called also plaster of Paris, selenite, and alabaster

HAD

Hade, in mining, the underlay or inclination of the vein

Half-pace, or *Haute-pace*, a raised floor in a bay window.

Half-timbered houses: this mode of constructing domestic buildings was practised in England and on the Continent during the reigns of Henry VIII. and Elizabeth. It was peculiarly of a picturesque character; the foundations and principal supports were of stout timber, and the interstices of the fronts were filled with plaster. In many cases the ornamental timber framing was of a dark colour, which, with the barge-board gable, gave the whole an exceedingly interesting appearrance. There are yet remaining some very fine examples in England, particularly in the western and north-western counties.

Half-timbers, in ship-building, those timbers in the cant bodies which are answerable to the lower fut-*tocks in the* square body

HAM

Hall, the principal apartment in the domestic houses of the middle ages; a place of assembly; a spacious building attached to inns of court

Halliards, in navigation, the ropes or tackles usually employed to hoist or lower any sail on its respective mast

Hallyings, the hangings of a hall

Halvans, in Cornish, the refuse ore

Ham, in Saxon, a house, farm, or village

Hamburgh lake is a colour of great power and depth; rather purpleish, or inclining to crimson: it dries with extreme difficulty, but differs in no other essential quality from other cochineal lakes

Hammer-beams, horizontal pieces of timber, frequently used in the roofs of old English buildings, in pairs on the opposite sides of the same roof; often used also in the principals of Gothic roofs, to strengthen the framing and to diminish the lateral pressure that falls upon the walls

Hances, in architecture, ends of elliptical arches, which are arcs of smaller circles than the scheme or middle part of the arch

Hand-brace, a tool for boring, consisting of a cranked spindle, at one end of which a broad head or breast-plate is attached by a swivel, so that it may remain stationary while the crank is turned; at the other end is a socket, into which a drill can be fixed

Hand-drilling machine, a small drilling machine turned by manual labour

Hand-gear, in a locomotive engine, the handles of the working gear, placed conveniently to the foot-plate, so as to be within reach of the engine-man when he requires to use them for regulating the different parts of the engine

Hand-pump, in a locomotive engine, the pump placed by the side of the fire-box, to be worked by a hand-lever when the engine has to stand with steam up

Hand-railing, in a locomotive engine, the railing along the sides of the engine, to protect persons passing to the front of the engine for any necessary purpose

Hand-saw, a saw from 12 to 15 inches in length, fixed in an iron frame, with a handle at one end; used for cutting wood or metal

Harmony is the general accordance of the objects in a painting with one another, and their subordination to the principal object; so that all unite to constitute a pleasing whole. It is effected by a due combination of lights and shades, by the union and colour, or by such constrasts as are sufficient to relieve the distant groups.

Harmony of colours. Lessons in colouring have ever been given, notwithstanding it is a part so principal in painting, that it has its rules founded on science and reason. Without such study, it is impossible that youth can acquire a good taste in colouring, or understand harmony.

Harpings, pieces of oak which hold the timbers of the fore-and-aft cant-bodies till a ship is planked

Hatches, the coverings for the hatchways of a ship, made with ledges, and laid with oak or deal, and caulked

Hatching is shadowing with a black-lead pencil or pen: it is done either in straight lines or zigzag strokes, such as are seen in pencil drawings, or in pencilled backgrounds. It is used by engravers in etching.

Hatchment, in heraldry, an armorial escutcheon placed over a door in memory of a deceased person of rank

Hatchways, places in the middle of the decks of a vessel, for the convenience of lowering down goods

Haul the wind, in navigation; to direct the ship's course nearer to the point of the compass from which the wind blows

Haunch of an arch, the part between the vertex and the springing

Hawse, in navigation, the situation of the cables before the ship's stern when she is moored with two anchors forward from the starboard and larboard bow

Hawse-pieces, the timbers in the bow of a ship whose sides are nearly parallel to the middle line

Hawthorn, a wood not much used, is hard, and of a whitish colour, with a tinge of yellow

Hazel, a small underwood which is very elastic, used for turning, for the handles of blacksmiths' chisels, for the hoops of casks, &c.

Head-ledges, the thwartship pieces which frame the hatch-ways or ladder-ways of ships

Head-stocks, the frames which support the centres of a lathe; viz. the mandril-frame and the poppet-head, or back centre frame

Health of Towns, a phrase recently coined to express the general purpose of public sanatory measures. These measures are based upon the principles of animal physiology, but

had been recognized only in the curative policy of the physician, until the evils of their neglect were traced by statistical inquiries into the causes of disease; and they are therefore now properly regarded as essential objects in the social economy of life.

The human constitution is so formed that its health depends on an adequate supply of pure air, water, and light. Every circumstance, therefore, which vitiates the quality, or reduces the due quantity, of these essentials, is injurious to health, and demands amendment or extinction.

Thus the efficient supply of pure and attemperated air requires proper drainage and ventilation, warming or cooling of all places in which human beings live or congregate: it also limits the minimum of size for the healthy habitations of men.

The plentiful supply of pure water necessitates suitable provision for obtaining and treating it, and the proscription of all arrangements which limit the service or injure its purity. Equally important with these conditions is the third one enumerated, which suggests the necessity of so arranging and constructing streets and buildings, that abundance of light may at all times be admitted into them.

As measures auxiliary to these objects, and of great importance in the combined arrangements of society, public exercising and pleasure grounds, baths and washhouses, cooking apparatus, medical and remedial establishments, street accommodations, &c., command adoption, and, when adequately carried out, will tend to complete the physical requisites of the health of towns.

Heat, in the ordinary application of the word, signifies, or rather implies, the sensation experienced upon touching a body hotter, or of a higher temperature, than *the part or parts* which we bring into contact with it: in another sense, it is used to express the cause of that sensation. To avoid any ambiguity that may arise from this double use of the same expression, it is usual and proper to employ the word *caloric* to signify the principle or cause of the sensation of heat. On touching a hot body, caloric passes from it, and excites the feeling of warmth: when we touch a body having a lower temperature than our hand, caloric passes from the hand to it, and thus arises the sensation of cold.

Caloric is usually treated of as if it were a material substance; but, like light and electricity, its true nature has yet to be determined.

COMMUNICATION OF CALORIC.

Caloric passes through different bodies with different degrees of velocity. This has led to the division of bodies into *conductors* and *non-conductors* of caloric: the former includes such bodies as metals, which allow caloric to pass freely through their substance; and the latter comprises those that do not give an easy passage to it, such as stones, glass, wood, charcoal, &c.

Table of the relative conducting power of different bodies.

Gold	1000
Platinum	981
Silver	973
Copper	898
Iron	374
Zinc	363
Tin	304
Lead	180
Marble	24
Porcelain	12·2
Fire-brick	11
Fire-clay	11·4
With Water as the standard.	
Water	10
Pine	39
Lime	39
Oak	33
Elm	32
Ash	31
Apple	28
Ebony	22

Relative conducting power of different substances compared with each other.

Hares' fur	1·315
Eider-down	1·305
Beavers' fur	1·296
Raw silk	1·284
Wool	1·118
Lamp-black	1·117
Cotton	1·046
Lint	1·032
Charcoal	·937
Ashes (wood)	·927
Sewing silk	·917
Air	·576

Relative conducting power of fluids.

Mercury	1·000
Water	·357
Proof Spirit	·312
Alcohol (pure)	·232

RADIATION OF CALORIC.

When heated bodies are exposed to the air, they lose portions of their heat, by projection in right lines into space, from all parts of their surface.

Bodies which radiate heat best, absorb it best.

Radiation is affected by the nature of the surface of the body; thus black and rough surfaces radiate and absorb more heat than light and polished surfaces.

Table of the radiating power of different bodies.

Water	100
Lamp-black	100
Writing-paper	100
Glass	90
Indian ink	88
Bright lead	19
Silver	12
Blackened tin	100
Clean do.	12
Scraped do.	16
Ice	85
Mercury	20
Polished iron	15
Copper	12

Professor Leslie has proved, by a variety of experiments, that the heat which is propagated by radiation from different bodies varies with the nature of their external surfaces; the quantity which flows in a given time from a body with a polished surface being much less than would flow from the same body with a rough surface. It therefore follows that the external surfaces of the steam-pipes of steam engines and steam cylinders should be as smooth as possible, and should be covered with any body which is a bad conductor of heat.

Heel tool, a tool used by turners for roughing out a piece of iron, or turning it to somewhat near the intended size: it has a very acute cutting edge and an angular base or heel

Height of columns. The height of a column is measured by its diameter immediately above the base.

	Diameters high.
The Tuscan column	7
The Ionic	9
Corinthian and Composite	10

In the above heights are included the capitals and bases, which are esteemed parts of the columns with which they are used.

Heights and Distances. Trigonometry receives its principal practical application in the operations of surveying, and measuring heights and distances; as, however, the methods of its application (depending on the peculiar circumstances of each case) are exceedingly various, no general rules can be specified.

The instruments employed to measure angles are quadrants, sextants, theodolites, &c., the use of either of which may be sooner learned from an examination of the instruments themselves than from any description independently of them. For military men and for civil engineers, a good pocket sextant and an accurate micrometer (such as Cavallo's), attached to a telescope, are highly useful. For measuring small distances, as bases, 50-feet and 100-feet chains, and a portable box of graduated tape, will be necessary.

For the purposes of surveying, it

is usual to employ a chain 66 feet in length, subdivided into 100 links, each 7·92 inches: the reason for using a chain of this length is, that ten of such square chains are equal to an acre, and therefore the acreage of the several divisions of an estate is found with much greater facility when measured in chains and links, than when the measurements are taken in feet.

Helix, the small volute under the abacus of a Corinthian capital

Helix, any thing of a spiral form, whether in one plane, as the spiral curve, or in different planes, as the screw

Heptagon, in geometry, a figure with seven sides or angles

Heraldry is a science intimately connected with the early history of Europe, its chivalry, its conquests, and the bearing of arms: it teaches how to blazon or explain in proper terms all that belongs to arms; and how to marshal or dispose with extreme punctualness divers arms on a field. It is in its archæology and in precedent indisputable. It teaches whatever relates to the marshalling of solemn processions and other public ceremonies, at coronations, installations of Knights of the Garter, Knights Grand Cross of the Bath, Knights Companions, &c.; at the creation of peers, nuptials, christenings of princes, funerals, &c. It is, in fact, an important science, particularly in English history, in tracing the narrative of the families of the nobility and commoners, their holdings, their distinguishing qualifications, in arms, in literature, and in the arts.

Hermæ, statues of which only the head is carved, and sometimes a portion of the bust: square or cubical figures of the god Mercury, without legs and arms, anciently placed by the Greeks and Romans at their cross-ways

Herring-bone work, masonry in which the stones are laid aslant instead of being bedded flat

Herse, a portcullis; a frame whereon lighted candles were placed at the obsequies of distinguished persons

Heterogeneous, opposite or dissimilar in nature, as opposed to homogeneous

Hewns, in Cornwall, the sides of a calciner or burning-house furnace; so called from their being formerly built with hewn moor-stone

Hexagon, in geometry, a figure of six sides or angles

Hexahedron, in geometry, one of the five regular solids, being the same with a cube

Hexastyle, a portico of six columns in front

Hexastylos, a frontage of six columns

Hexeres, a vessel with six banks of oars on each side

Hiatus, an aperture, a breach or defect

Hick's mandril, an arbor for turning rings: at the centre of the arbor there is a cone, round which, at equal distances, wedges are fitted into dove-tailed grooves, and are expanded to the bore of the ring by a nut acting on a screw at the end of the cone

Hickory, or *white walnut*, a native of America. The wood of the young trees is exceedingly tough and flexible, and makes excellent handspikes, &c.

Hieroglyphic, an emblem, a figure by which a word is implied; the Egyptian art of writing in picture

High-pressure engine, a non-condensing steam engine, worked by the excess of the pressure of the steam upon the piston above the pressure of the atmosphere: in this engine, after the steam has acted upon the piston, it passes through the eduction-pipe into the air

Hiling, the covering or roof of a building

Hinges, the joints on which doors, gates, &c., turn

Hinges. The diversity of forms into which door furniture has been resolved is almost endless. Many of the ancient hinges were not only

wrought into scrolls and other florid devices, but occasionally further enriched with inscriptions.

Hip, the external angle formed by the meeting of the sloping sides of roofs which have their wall-plates running in different directions

Hip-knob, a pinnacle, finial, or other similar ornament, placed on the top of the hips of a roof or the point of a gable

Hippodrome, a large plot of ground laid out for the exercise of horses; among the Greeks, a race-course

Hoggan, in Cornish, a hawthorn-berry, the tinner's pasty

Hogging, in ship-building, the convex appearance resembling the back of a hog, given to a ship after being first launched, by the dropping of the two extremities

Hogshead, a measure of 63 gallons

Hoist, an apparatus for raising bodies from the ground floor of a building to a floor above

Hollow newell, an opening in the middle of a staircase, the steps only being supported at one end by the surrounding wall, the ends next the hollow unsupported; also a hollow groin, pier, of brick or stone, made behind the lock-gates of canals

Holly is a very clean, fine-grained wood, the whitest and most costly of those used by the Tunbridge-ware manufacturers: it is used for painted screens and a great variety of fancy and tasteful purposes

Holy-water vessel, the vessel which contains the consecrated or holy water carried in religious processions: also the receptacle for holy water placed at the entrances of Roman Catholic churches

Holy-water stone, the stoup on which the holy-water vessel is placed

Homestall or *Homestead*, a mansion, house, or seat in the country; a farm, with the land adjoining

Homogeneous, a term applied to various substances, to denote that they consist of similar parts, or parts of the same nature and kind

Hoodings-ends, the ends of planks which fit into the rabbets of the stem and stern-post of a ship

Hood-mould, a band or string over the head of a door, window, or other opening, in an ancient building; so called from its enclosing, as within a hood, the inferior mouldings and the opening itself

Hood-moulding, a name given to the label-moulding

Hornbeam, a very tough and stringy European wood, used by millwrights for the cogs of wheels, also for plumbers' dressers, or mallets, &c.

Hornblende, a conspicuous ingredient in the composition of rocks, divided into common hornblende, hornblende-schist, and basaltic hornblende

Horn-stone, a conchoidal and silicious mineral substance, allied in composition to flint, but of a more earthy texture

Horologium, a name anciently given to any instrument for measuring time

Horse, a large round bar of iron fixed in the head of a ship

Horse, in navigation, the name of a rope reaching from the middle of a yard to its extremity, on which the sailors stand when they are loosing or reefing the sails

Horse-chestnut wood is one of the white woods used by the Tunbridge turners; it is close and soft, even in the grain, and is much used for brush-backs, &c.

Horse-power. Although horses are not all of one strength, yet there is a certain force now generally agreed upon among those who construct steam engines, which force is denominated a *horse's power*, and hence steam engines are distinguished in size by the number of horses' power to which they are said to be equal.

The measure of a mechanical effect equal to a horse's power has been much disputed: this, however, can be but a matter of little consequence, if the measure be generally understood, since there is no such thing as bringing it into any real

measure. Some horses will perform double the work of others, and those of one country will work more than those of another. Desaguliers' measure is, that a horse will walk at the rate of 2½ miles per hour, against a resistance of 200 lbs., and this gives, as a number for comparison, 44,000; that is, the raising of 1 lb. 44,000 feet in a minute, or, what amounts to the same, the raising of 44,000 lbs. 1 foot in a minute.

Emerson's measure is the same as Desaguliers', and Smeaton's result is 22,916 lbs. under the same circumstances.

James Watt found from repeated experiments, that 33,000 lbs. 1 foot per minute was the average value of a horse's power; but his engines were calculated to work equal to 44,000 lbs. 1 foot per minute.

H. P., the abbreviation for horse-power

Hortus, a garden or a pleasure-ground

Hose-pipes, in locomotive engines, elastic pipes made of canvas, saturated with a solution of Indian rubber, sometimes galvanized, and forming a good elastic connection between the engine and tender feed-pipes. They are now generally used in preference to ball and socket connections for conveying the steam to the tender.

Hospitalia, anciently the doorways in the scene of a theatre on the right and left of the valvæ regiæ or principal doorway; so called because the moveable scenes, representing inns or places appropriated for the reception of strangers, were placed near them

Hospitals were originally designed for the relief of poor and impotent persons, and the entertainment of travellers upon the road, particularly of pilgrims, and therefore they were generally built upon the roadside; in later time they have always been founded for fixed inhabitants: before the spoliation, there existed in England above 358 of these *houses of relief*

Hostelry or *Hostry*, anciently an inn

Hot-air blast. It was conceived that the presence of sulphur in the air was the cause of blast furnaces working irregularly, and making bad iron in the summer months. Subsequently it was stated that one of the Muirkirk iron furnaces, in Scotland, situated at a considerable distance from the engine, did not work so well as the others, which led to the conjecture that the friction of the air, in passing along the pipe, prevented an equal volume of the air getting to the distant furnace as to the one which was situated close by the engine: it was considered also, that by heating the air at the distant furnace, its volume would increase in the ratio of the known law, that air and gases expand to double their bulk at 448° temperature.

Example: If 1000 cubic feet, say at 50° of Fahrenheit, were pressed by the engine in a given time, and heated to 600° of Fahrenheit, it would then be increased in volume to 2104·4, and so on for every thousand feet that would be blown into the furnace. In prosecuting the experiments which this idea suggested, circumstances, however, became apparent which induced a belief, that heating the air introduced for supporting combustion into air furnaces materially increased its efficiency in this respect; and with the view of putting these suspicions to the test, the following experiments were made.

To the nozzle of a pair of common smith's bellows, a cast-iron vessel heated is attached from beneath, in the manner of a retort for generating gas, and to this vessel the blow-pipe, by which the forge or furnace was blown, was also attached. The air from the bellows having thus to pass through the heated vessel above mentioned, was consequently heated to a high temperature before it entered the forge fire, and the result produced, in

increasing the intensity of the heat in the furnace, was far beyond expectation, and so evident as to make apparent the fallacy of the generally received opinion, that the coldness of the air of the atmosphere in the winter months was the cause of the best iron being then produced.

In overthrowing the old theory, new principles in the process of iron-making were established.

Experiments on the large scale, to reduce iron ore in a founder's cupola, were commenced at the Clyde Iron Works. These experiments were completely successful, and in consequence the invention was immediately adopted at the Calder Iron Works, where the blast, being made to pass through two retorts placed on each side of one of the large furnaces before entering the furnace, effected an instantaneous change, both in the quantity and quality of iron produced, and a considerable saving of fuel.

The whole of the furnaces at the Calder and Clyde Iron Works were filled up on the principle of the hot blast, and its use at these works continues to be attended with the utmost success; it has also been adopted at Wilsontown and Gartshirrie Iron Works in Scotland, and at several works in England and France.

The air as at first raised to 250° of Fahrenheit produced a saving of three-sevenths in every ton of pig iron made, and the heating apparatus having since been enlarged, so as to increase the temperature of the blast to 600° Fahrenheit and upwards, a proportional saving of fuel is effected; and an immense additional saving is also acquired by the use of raw coal instead of coke, which may now be adopted. By thus increasing the heat of the blast, the whole waste incurred in burning the coal into coke is avoided in the process of making iron.

By the use of this invention, with three-sevenths of the fuel formerly employed in the cold-air process, the iron-maker is now enabled to make one-third more iron of a superior quality.

Were the hot blast generally adopted, the saving to the country in the article of coal would be immense. In Britain, about 700,000 tons of iron are made annually, of which 50,000 tons only are produced in Scotland: on these 50,000 tons would be saved, in the process of manufacture, 200,000 tons of coal annually. In England the saving would be in proportion to the strength and quality of the coal, and cannot be computed at less than 1,520,000 tons annually; and taking the price of coals at the low rate of four shillings per ton, a yearly saving of £296,000 sterling would be effected.

Nor are the advantages of this invention solely confined to iron-making: by its use the founder can cast into roods an equal quantity of iron in much less time, and with a saving of nearly half the fuel employed in the cold-air process; and the blacksmith can produce in the same time one-third more work, with much less fuel than he formerly required.

In all the processes of metallurgical science it will be found of the utmost importance in reducing the ores to a metallic state.

Hot-water pump, the feed-pump of a condensing engine, for supplying the boiler from the hot well

Hot well, the vessel which receives the water from the air-pump

Hour-glass stand, a bracket or frame of iron for receiving the hour-glass. See 'Papers on Architecture,' vol. iii., which contains a good example. "By the side of the pulpit still remains the ancient hour-glass and frame."

House, a place of residence. The purpose of a house being for dwelling, and that of tents being the same, they are called by one name in the Hebrew; on the same principle, the

Tabernacle of God, though only a tent, is sometimes called the Temple, that is, the residence of God. The ordinary buildings or houses in the East have continued the same from the earliest ages, without the least alteration or improvement;—large doors, spacious chambers, marble pavements, cloistered courts, with fountains, &c.,—conveniences well adapted to the circumstances of these climates, where the summer heats are generally intense. The streets of these cities, the better to shade them from the sun, are usually narrow, with sometimes a range of shops on each side. On entering one of the principal houses, a porch or gateway will first be seen, with benches on each side, where the master of the family receives visits and dispatches business. In houses of better fashion, the chambers are hung with velvet or damask from the middle of the wall downwards, and covered and adorned with velvet or damask hangings of white, blue, red, green, or other colours. The ceiling is generally of wainscot, either very artistically painted, or else thrown into a variety of panels with gilded mouldings, and with scrolls of the Koran, &c. The stairs are sometimes placed in the porch, sometimes at the entrance into the court. When there is one or more stories, they are afterwards continued, through one corner or other of the gallery, to the top of the house, whither they conduct through a door that is generally kept shut, to prevent their domestic animals from daubing the terrace, and thereby spoiling the water which falls from thence into the cisterns below the court, &c. Such in general are the manner and contrivances of the Eastern houses; and *if it may be* presumed that our *Saviour, at the* healing of the paralytic, *was preaching* in a house of *this fashion,* it may, by attending *only to the* structure of it, throw some light on one circumstance of that history, which has given great offence to some unbelievers. The houses of the poorer class of people in the East are of very bad construction, consisting of mud walls, reeds, and rushes. In Constantinople every thing is sacrificed to outside decorative show: built principally of wood, conflagrations are frequent and extensive. In earlier history, magnificence and refined luxury were combined with the highest and most noble examples of decorative art. The interior of the domestic residences and public edifices of Herculaneum and Pompeii surpassed every existing example. The houses of the Roman citizens partook also of the refinement of an age of art; and modern Europe has noble examples of domestic dwellings, coeval with the wealth of the country in which they are still to be found. In England, the domestic residence of the nobleman, the merchant, and the trader are, besides the elegances of their arrangements, models of comfort and health.

Houses. Before a house is planned, the proprietor should describe the kind of house he wishes to be built. The architect is to consider what must be had, and what may be dispensed with. He ought to keep his plan as scrupulously within the expense proposed, as within the limits of the ground he is to build upon; he is, in short, to enter into the views, the wishes, and the ideas of the gentleman who will inhabit the house proposed to be erected.

Houses suitable to the different ranks of the community.—Vitruvius instructs us of those parts of private houses which are exclusively appropriated to individuals of the family, and in what manner these ought to be connected with the apartments into which strangers are admitted; for there are several parts of a house which may not be approached by those who are not of the household.

unless expressly invited; such as the sleeping-rooms, triclinia, baths, and those apartments which are in general use. The parts which are accessible to all, and into which any person may enter uninvited, are the vestibule, cavædium, peristyle, and whatever others are built for similar purposes.

Houses. Of the proportions of private houses, Vitruvius says,—"Nothing ought to engage the attention of an architect more than the proportions of all the parts in the houses he constructs: after having determined upon such proportions as the necessity for the commensuration of the parts with the entire building seems to require, the greatest judgment must be exercised in adapting them to the nature of the spot, the use to which the edifices are designed, and the appearance they ought to assume; and this must be done by making such additions or deductions, that, although the proportions are not strictly what they ought to be, the eye may not be conscious wherein they fail. The same objects appear differently under dissimilar circumstances; if near the ground or at a considerable elevation; if in a confined space or an exposed situation. Under every peculiar circumstance, great judgment is necessary in calculating the effect which will be ultimately produced. The impression made upon the sense of seeing is not always a correct image of the object; for, in painting, columns, mutules, and statues are made to appear projecting and detached, when, in fact, every object represented is in one and the same place. It becomes necessary, in the first place, to institute laws of proportion, upon which all our calculations must be founded. According to these, the ground-plan, exhibiting the length and breadth of the whole work and the several parts of it, must be formed. When the magnitude of these is once determined, the parts must be arranged so as to produce that external beauty which suffers no doubt to arise in the minds of those who examine it as to the want of proportion in any part."

Houses of the Greeks.—The Greeks had a different way of building from the Romans; for, as Vitruvius says, "instead of making porticoes or galleries and halls, they made the entry to their houses very narrow, placing on one side the stables, and the porter's lodge on the other. From this first entry one passed into a court, which had piazzas on three sides, and towards that of the south they made anti, or abutments of pilasters, which supported the joists of the ceiling more inwards; because that leaving some space between the one and the other, they had very large places, which they appointed for lodging to the mistress of the house, and to the men and women servants. On the same floor with these abutments there were some rooms which may be called ante-chambers, chambers and drawing-rooms, being every one just behind the other."

Housing, a tabernacle, or niche for a statue, was formerly so called

Huel, a work, a mine, as huel stones, a tin mine

Hulk, in Cornwall, an old excavated working; 'to hulk the lode'

Hulk or *hull*, the body of a ship

Hungarian machine, an hydraulic engine, a very ingenious application of the Hero *jet-d'eau* principle

Hydraletes, according to Strabo, a mill for grinding corn by water-power

Hydraulic belt, an endless double band of woollen cloth, passing over two rollers, the lower part of the belt being immersed in water: it is driven with a velocity of not less than a thousand feet per minute, and the water contained between the two surfaces is carried up and discharged, as it passes over the upper roller, by the pressure of the band

Hydraulic ram, a machine contrived to raise water by means of its own momentum

Hydraulics. The science of hydraulics teaches the method of estimating the swiftness and force of fluids in motion. The science is dignified by the name of hydrodynamics, or the application of dynamics to the impulsion and flow of water and other liquids, as well as the forces with which they act upon bodies against which they strike, or which move in them.

Hydrodynamics, the science of the laws of the motion of fluids, consisting of two branches. The science of hydraulics refers principally to the machinery for conducting fluids; that of hydrostatics, to the pressure, equilibrium, and cohesion of fluids.

Hydrogen. Hydrogen gas is commonly obtained for experimental purposes by the decomposition of water: its name is derived from the Greek words meaning *water* and *to generate*.

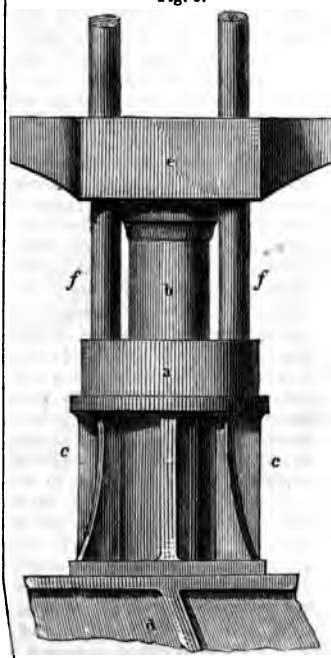
Hydrometer, an instrument for measuring the specific gravity of various spirits and other liquids, by floating in them

Hydroscope, an instrument intended to mark the presence of water in air

Hydrostatic or *Hydraulic press*, a machine adapted for acquiring great pressure in cases where little motion is required. The contrivance of this apparatus is due to the celebrated mechanician, Joseph Bramah, who obtained a patent for it on the 31st of March, 1796, under the title of 'certain new methods of producing and applying a more considerable degree of power to all kinds of mechanical apparatus and other machinery requiring motion and force, than by any means at present practised for that purpose.' The action of this press is founded *upon the fundamental* principle in *hydrostatics, that* "when a liquid *mass is in equilibrium*, under the *action of forces of* any kind, every molecule or part of the mass sustains an equal pressure in all directions." From this it follows, that a pressure exerted on any portion of the surface of a confined mass of fluid is propagated throughout the mass, and transferred undiminished to the entire surface in contact with the water. The first suggestion of the hydraulic press is considered to have been made by Pascal in the middle of the 17th century; but Bramah was the first to carry this suggestion into practice, by devising and applying apparatus in various forms for the purpose of producing pressure.

Since the date of its invention, the hydraulic press has been extensively used in pressing goods of various kinds. Another of its most useful applications is to the testing

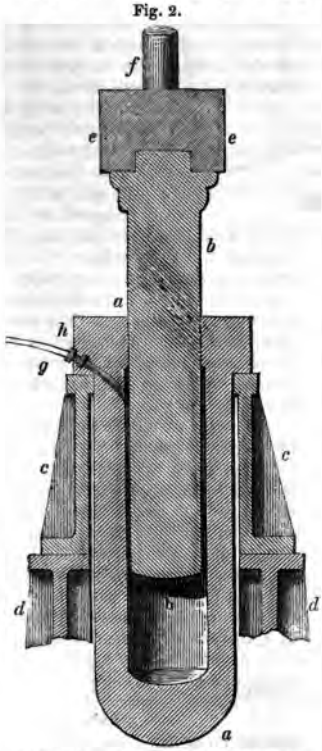
Fig. 1.



of girders and beams of cast iron. (See article, *Bramah's hydrostatic press.*) Its latest and perhaps most remarkable duty is that of lifting the iron-work of tubular bridges *en masse* from the water level to their final altitude.

Hydrostatic presses consist essentially of two distinct parts, viz. the *press*, or machine in which the force acquired is applied, and the *pumping apparatus*, by which the water is forced into the press; these two parts of the entire machine being connected only by the pipe

Fig. 2.

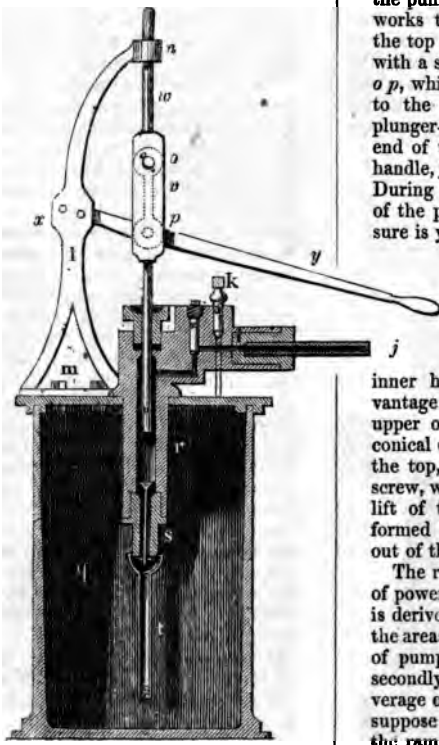


through which the water passes from one to the other. Of the accompanying *figures*, Nos. 1 and 2 show the main parts of the press, viz. the cylinder, into which the water is admitted; the ram, or solid plunger or piston; and the cross-head by which the pressure at the end of the ram is distributed over a lengthened surface for use. The figures show the cylinder as supported in a frame upon girders, in a manner similar to that adopted in raising the tubes of the railway bridge recently erected at Conway.

Fig. 3 shows the section of a portable forcing-pump as commonly used for proving castings with the hydraulic press, for which purpose the press is applied horizontally, and mounted on an iron carriage for portability. But, however varied in arrangement for particular purposes, the pump and the press consist of the same essential parts, as follows: the pump comprises a cistern or kind of pail, for containing the water, and into which a barrel descends nearly to the bottom. The barrel is fitted with a plunger, by working which, the water is driven through a small tube or pipe into the press. The pump is furnished with a safety-valve, and also with a screw for letting off the water as required. The press consists of a strong hollow cylinder of cast iron, close at one end, and of a solid ram working through the other end, the water-pipe being inserted through the metal of the cylinder in a water-tight screwed aperture. Fig. 1 is an elevation of the press; fig. 2, a vertical section of the press, taken at right angles to the elevation; and fig. 3, a vertical section of a pump: *a* is the cast-iron cylinder; *b*, the ram; *c*, the casing or frame of the cylinder; *d d* are two cast-iron girders supporting the casing; *e* is the cast-iron cross-head; *f f*, two guide-rods; *g*, the water-pipe from the pump, with a lever-valve at *h*, by closing which the pressure will be retained, should the pipe burst. On fig. 3, *j* shows the other

end of the water-pipe, which is at *i* screwed into a stuffing-box on the pump; *k* is the lever of the safety-valve, *a'*, which is cylindrical, and finished with a conical end, which fits a seating of similar form; *l* is a standard bolted at *m* to the cover

Fig. 3.



of the cistern, and having an eye-boss at *n*, for guiding the plunger; *o p* is a link pinned to the plunger; *q* is the pail or cistern for holding the water; *r*, the barrel passing through an opening in the cover, and fixed to it with bolts and nuts; *s*, the lower valve-seat, and conical three-sided valve, the former being screwed into the end of the barrel; *t*, a tube depending from the valve-seat *s*, and screwed upon it: this tube reaches nearly to the bottom of the cistern, and is perforated at the end with minute apertures, through which the water is admitted without dirt or particles, which would injure the working of the pump; *u* is the plunger, which works through a stuffing-box on the top of the barrel, and is made with a slot at *v*, to receive the link *o p*, which is pinned to it and also to the pump-handle; *w* is the plunger-rod, screwed into the upper end of the plunger; *y*, the pump-handle, jointed to the standard at *x*. During the first part of the action of the pump, while no great pressure is yet produced, the handle is pinned to the outer of these holes, as it makes a larger stroke with the piston, and thus saves time: the pin is afterwards removed to the inner hole, to have all the advantage of the leverage. *z* is the upper or discharge valve, with a conical end: it is introduced from the top, and covered with a short screw, which likewise regulates the lift of the valve. This valve is formed by being simply filed flat out of the round.

The rule for finding the increase of power commanded by the pump is derived,—first, from the ratio of the areas of cross section of plunger of pump and ram of press; and, secondly, from the ratio of the leverage of the pump-handle. Thus suppose the plunger to be ½ inch and the ram 6 inches in diameter, and the arms of the lever or handle as 1 to 4, the power will be thus found:

$$\begin{array}{rccc} & \cdot 5^2 & : & 6^2 \\ \text{multiplied by} & 1 & : & 4 \\ \hline & \cdot 25 & : & 144, \end{array}$$

that is, 1 : 576.

And thus a power equal to 20 lbs., applied on the end of the pump-handle, will produce a pressure

equal to 11,520 lbs. on the ram, or 5 tons 2 cwt. 3 qrs. 12 lbs.

Each of the presses applied at Conway was worked by a steam engine having a horizontal cylinder 17 inches in diameter and 16 inches stroke, with piston-rods working through stuffing-boxes at both ends of the cylinder. The piston-rods worked two forcing-pumps, with plungers $1\frac{1}{16}$ inch diameter and 16 inches stroke. The rams of these presses were each 5 feet 2 inches long and $18\frac{3}{8}$ inches in diameter, with a space nearly $\frac{1}{8}$ inch wide around. The cylinders were $37\frac{1}{2}$ inches diameter externally, and 20 inches internally, the metal being $8\frac{3}{4}$ inches in thickness: the orifice of the water-tubes $\frac{3}{8}$ inch in diameter.

Hydrostatic paradox. This may be explained upon the same principles as the mechanical powers; and an explanation conducted in this manner strips it of its paradoxical appearance.

Hydrostatics, the science which treats of the mechanical properties of fluids; strictly speaking, the weight and equilibrium of fluids. The weight and equilibrium of fluids at rest are the objects of this science. When the equilibrium is destroyed, motion ensues; and the science which considers the laws of fluids in motion is hydraulics.

Hygrometer: this instrument is used to ascertain the quantity of moisture held in the atmosphere. There are several kinds of hygrometers in use, namely, De Luc's, Saussure's, Leslie's, and Professor Daniell's. The latter is considered preferable.

Hypæthral, open above: in temples of this description the cella was in part exposed to the air: they had a double range of columns within the cella, dividing it into three alæ, or aisles. The alæ on either side were roofed, but that in the middle had no covering.

Hypætrum, a latticed window over the entrance-door of a temple

Hyperbola, a section of a cone made by a plane, so that the axis of the section inclines to the opposing leg of the cone, which in the parabola is parallel to it, and in the ellipse intersects it

Hyperthyrum, that part of the frame of a doorway which is over the supercilium

Hyperthyrum, in Greek architecture, a frieze and cornice supported by friezes and consoles

Hypocastanum, or *chestnut brown*, is a brown lake prepared from the horse-chestnut: it is transparent and rich in colour, warmer than brown pink, and very durable both in water and oil: in the latter it dries moderately well

Hypocausis, among the Greeks, a furnace with flues running underneath the pavement of an apartment, to increase the temperature

Hypocaustum, the stove-room of a bath, in which was placed the præfurnium for heating the caldaria

Hypogæum, in ancient architecture, a name common to all the underground parts of a building

Hypotrachelium, that part of the capital of a column which occurs between the shaft and the annulets of the echinus

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ICE IMP

Ice-house, a subterranean chamber for preserving ice free from mixing with the ordinary changes of temperature

Ich Dien, in heraldry, 'I serve'

Ichnography, in drawing. The ichnography of a building represents the plan or ground-work; the orthography the front; and the scenography the whole building.

Icosahedron, in geometry, a regular body or solid, consisting of twenty triangular pyramids

Image, a term applied to a statue

Imbowment, an arch or vault

Impages, the horizontal parts of the

frame-work of doors, commonly termed rails

Impale, in heraldry, to conjoin two coats or arms, as a wife's with those of her husband

Impetus, in mechanics, violent tendency to any point, violent effort, force, momentum, motion

Impinge, in mechanics, to fall against, to strike against, to clash with

Impluvium, the cistern in the central part of the court or atrium of a Roman house, to receive the rain-water

Impost, the horizontal mouldings or capitals on the top of a pilaster, pillar, or pier, from which an arch springs: in classical architecture the form varies in the several orders. Sometimes the entablature of the order serves for the impost of an arch.

Impost, *archivolt*, and *key-stone*. The height of the impost should be from one-ninth to one-seventh of the width of the aperture, and the breadth of the archivolt not more than an eighth nor less than a tenth of it. The breadth of the under side of the key-stone should be the same as the breadth of the archivolt, and its sides, of course, concentric; its length, once and a half its breadth, but not more than double its breadth.

Impulsive force is that which acts during an extremely short time, and is so called because the forces that take place in any impulse, or impact, are speedily exhausted

Incise, to cut; to engrave; to carve

Inclined plane (the), in mechanics, is a plane which makes with the horizontal plane any angle whatever, forming one of the simplest mechanical powers. The inclination of the plane is measured by the angle formed by two lines drawn from the sloping and the horizontal plane, perpendicular to their common intersection.

Increment, an increase; produce

Incrustation. If water, impregnated with calcareous matter, remains long in contact with extraneous substances, an earthy incrustation takes place that soon encloses the encrusted substance, which is then said to be petrified.

Indian Architecture consists of two distinct styles,—the Buddhist and the Brahminical,—the former being the earliest, and consisting of topes or tumuli, large domical buildings of brick or stone, either quite solid or containing one or more small chambers, in which are deposited relics, coins, and other similar objects, which the greater number of them were erected to enshrine.

The principal topes are now found in Ceylon and Affghanistan, but they also exist in Burmah and in other neighbouring countries.

The next class of Buddhist buildings are the Chaitya halls, similar in plan and use to the early basilicæ: these exist principally in caves in India. And lastly, viharas or monasteries, in which the monks attached to the Chaitya halls resided: these also exist principally as caves in India, and as structural buildings in all countries where Buddhism is still practised.

Brahminical or Hindoo architecture consists mostly of temples, properly so called. These in almost every instance are towers, square in plan, or nearly so, built over the cell or sanctum of the temple. In the south of India, the upper part forms a right-lined pyramid; in the north, the outline is curvilinear, sometimes tapering to a spire.

To these towers are attached porches of greater or less dimensions. In the north there are generally square halls without pillars—in the south, as universally pillared—sometimes attached, at others detached from the temple itself: in the latter case, in the south, some of the porches possess from 500 to 1000 pillars, though this is never the case in the north.

These temples are generally surrounded by a square court: in the

south, three, four, and sometimes even seven such enclosures surround the principal cell, the outer one being, in many instances, some miles in circumference.

These Hindoo temples exist sometimes, though rarely, as rock-cut temples; but generally they are structural.

Between these styles comes a third, the Jaina style, being a mixture of the two, possessing some of the characteristics of both, and frequently displaying more elegance than the first, and less tawdriness than the other. By the introduction of domes, whose use was thus brought to great perfection, an element was added which was a great improvement on the other two styles, and from which that of Jaina originated.

The absence of the arch in all constructions of every age is general throughout India, as the principle was quite unknown. The upper parts of the buildings were supported on square piers or pillars, and from all sides of their capitals brackets projected equal to their width, and leaving generally a space equal to three diameters between their greatest projection, thus leaving only one-half of the whole length of the architrave unsupported; but when a greater space was required, a succession of projecting brackets, placed above each other, was adopted, sometimes meeting in the centre, and thus having the effect of the horizontal arch.

Indian Ink: the pigment well known under this name is principally brought from China in oblong cakes, of a musky scent, prepared for painting in water, &c.

Indian red, a colour, is brought from Bengal, and is a very rich iron ore, or peroxide of iron. It is an anomalous red, of a purple-russet hue, of a good body, and valued, when fine, for the pureness and lakey tone of its tints

Indian yellow is a pigment long employed in India and subsequently introduced generally into painting in European countries. It is imported in the form of balls, is of a fetid odour, and is produced from the urine of the camel. It has also been ascribed, in like manner, to the buffalo, or Indian cow, after feeding on mangoes; but the latter statement is incorrect. Indian yellow resists the sun's rays with singular power in water-painting.

Indicator, the apparatus for showing the force of the steam, and the state of exhaustion in the cylinder during the stroke

Indigo, or *Indian blue*, is a pigment manufactured in the East and West Indies from several plants, but principally from the anil or indigofera

Inertia, the passiveness of matter: matter has not the power of putting itself into motion, neither has it the power of stopping itself when put into motion by the action of an external force, as it requires as much force to stop a body as it requires to put it in motion

Inflammable air, hydrogen gas

Influx, in hydraulics, the act of flowing into any thing, as the tide into a bay or river

Injection-cock, the stop-cock in the ejection-pipe, for shutting off the supply of cold water used for the condensation of steam

Injection-pipe, the pipe through which the injection water passes to the condenser; in a steam vessel the injection-pipe is open to the sea, at the bottom of the vessel

Inn or *Hostel*, anciently a lodging-house, or a house of lodging and refreshment for travellers: houses for lodging the collegians at Cambridge and Oxford were so called

Inns of court, houses in which there are many lodgings for the accommodation of students and practitioners at law

Innate force, in physics, the vis inertia

Inner-post, in ship-building, a piece brought in at the fore-side of the

main-post, and generally continued as high as the wing-transom, to seat the other transoms upon

Insertum opus, according to Vitruvius, a mode of building walls used by the Romans, in which the stones were small and unhewn, similar to what is now called rubble-work

Insulated columns, in architecture, are those which are unconnected with any wall or building

Intaglio, in sculpture, &c., any thing that has figures engraved on it, so as to rise above the ground

Intense blue, indigo refined by solution and precipitation, in which state it is equal in colour to Antwerp blue. By this process, indigo also becomes durable, and much more powerful, transparent, and deep. It washes and works well in water; and in other respects it has the common properties of indigo.

Intercolumniation. The space between two columns is called an intercolumniation. When columns are attached to the wall, this space is not under such rigorous laws as when they are quite insulated; for, in the latter case, real as well as apparent solidity requires them to be near each other, that they may better sustain the entablatures which it is their office to carry.

Different sorts.—The different intercolumniations had the following names bestowed on them by the Greeks, and they still retain their ancient appellations:

Pycnostylos, when the columns are once and a half of their diameter distant from each other.

Systylos .. when their distance from each other is two diameters.

Eustylos .. when their distance from each other is two diameters and a quarter.

Diastylos .. when their distance from each other is three diameters and a quarter.

Aræostylos.. when their distance from each other is four diameters.

In the Doric, however, the intercolumniation is regulated by the disposition of the triglyphs in the frieze; for the triglyph ought always to be placed over the centre of a column, and the metope should be square. In the Tuscan interval, the architraves being of wood, the space may be considerably extended.

A strict adherence to the above-named intervals between the columns produces some irregularity in the arrangement of the modillions and dentils of the Corinthian, Ionic, and Composite cornices, which, though not offensive, is better avoided. Vignola therefore has, with some propriety, made his eustylos intercolumniation equal to two diameters and one-third in all but the Doric order.

Intercolumniations. Columns may be said to be either engaged or insulated: when insulated, they are either placed very near the walls or at some considerable distance from them.

With regard to engaged columns, or such as are near the walls of a building, the intercolumniations are not limited, but depend on the width of the arches, windows, niches, or other objects, and their decorations, placed within them. But columns that are entirely detached, and perform alone the office of supporting the entablature, as in peristyles, porches, and galleries, must be near each other, both for the sake of real and apparent solidity.

The ancients had several manners of spacing their columns, which are described by Vitruvius in his third and fourth books. Those practised in the Ionic and Corinthian orders were, the pycnostyle, the systyle, the eustyle, the diastyle, and the aræostyle.

In the Doric order they used other intercolumniations, regulating them

by the triglyphs, of which one was always to be placed directly over the middle of each column, so that they were either systyle monotriglyph, of one diameter and a half; diastyle, or araeostyle: the Tuscan intervals were exceedingly wide, some of them being above seven diameters, which, as the architraves were of wood, was practicable.

Vitruvius intended the five intercolumniations, mentioned in his 3rd book, merely for the Ionic and Corinthian orders; the latter of which, according to him, differed from the former only in its capital; for, in the second and seventh chapters of his fourth book, he establishes other intervals for the Doric and Tuscan orders. Nevertheless, they have employed these intercolumniations in different orders. Palladio has used the systyle in the Corinthian, and the araeostyle in the Tuscan; by which means the Corinthian peristyle, of which the character should be extreme delicacy and lightness, becomes twice as strong and material as the Tuscan, of which the distinguishing characteristics ought to be extreme solidity.

Interlignium, in ancient architecture, the space between the ends of the tie-beams

Interpensivæ, timbers in the roof of the cavædium, extending in a diagonal direction from the angles made by the walls of the court to the angles made by the junction of the beams supporting the roof

Intrados, the soffit or under-surface of an arch, as opposed to *extrados*

In vacuo, a void or empty space

Invention, in painting, consists principally in three things: first, the choice of a subject properly within the scope of art; secondly, the seizure of the most striking and energetic moment of time for representation; and lastly, the discovery and solution of such objects, and such probable incidental circumstances, as, combined together, may best tend to develop the story, or augment the interest of the piece. The cartoons of Raphael furnish an example of genius and sagacity in this part of the art.

Inverse, turned back or inverted; opposed to *direct*

Inverse ratio, when more requires less, or less requires more

Inverted arch, an arch of stone or brick, with the crown downwards, commonly used in the construction of tunnels

Iodine scarlet is a new pigment, of a peculiarly vivid and beautiful colour, exceeding even the brilliancy of vermillion. It has received several false appellations, but is truly an iodide or biniodide of mercury, varying in degrees of intense redness. It has the body and opacity of vermillion, but should be used with an ivory palette-knife, as iron and most metals change it to colours varying from yellow to black.

Iodine yellow, ioduret of lead, is a precipitate from an acid solution of lead by an alkaline solution of iodine, of a bright yellow colour, which, from its active chemical affinities, and the little experience of its qualities in painting, is to be employed with doubt and caution

Ionic capital. The Greek architects must have possessed much science in the formation of curves of every description. We cannot generate the curve of the volute of an Ionic capital but by approximation; but the inventors of the order must have known how to generate this and other curves in Greek architecture, on fixed principles; so must the artist in vases, &c. Mr. Jopling is said to have discovered the true generic curve.

Ionic Order: this, says Palladio, "had its origin in Ionia, a province of Asia; and we read that the famous temple of Diana at Ephesus was built of that order. The column, with its capital and base, is nine modules high; and by a module is understood the diameter of a column below. The architrave, frieze, or

cornice, have the fifth part of the height of the column. When the columns are single, the inter-columns are of two diameters and a fourth part, and this is the most beautiful and commodious manner of all inter-columns, which Vitruvius calls eustylos."

Amongst the ancients, the form of the Ionic profile appears to have been more positively determined than that of any other order; for in all the antiques at Rome, the temple of Concord excepted, it is exactly the same, and conformable to the description which Vitruvius has given of it.

Modern artists have likewise been more unanimous in their opinions upon the subject; all of them, excepting Palladio and his imitators, having employed the dentil cornice, and the other parts of the profile, nearly as they are found in the Coliseum, the temple of Fortune, and the theatre of Marcellus.

In Palladio's works we meet with three different Ionic entablatures; all of them very beautiful. The first is the true antique, which he has made use of at the palace of the Porti; and in several doors and windows of the Thiene and Valmarana palaces, in Vicenza. The second is a very judicious imitation of the entablature in the temple of Concord, and is executed by him in the upper arcade of the basilica in the same city. The third, which is an invention of his own, being the same with that in his book, he has employed with some small difference at the Chiericato palace, at the rotunda of Marchese Capra, and in various others of his buildings in the Vicentine, or at Venice.

Iron, the most useful and the most abundant of the metals, is found in various conditions of ore in most parts of the earth. Those ores which are principally worked for the production of the metal for manufacturing purposes, are either oxides or carbonates, that is, they contain the metal in a state of combination either with oxygen, or with oxygen and carbonic acid. The oxides are the best ores, and are found in vast beds in Sweden: the carbonates are inferior in point of strength and ductility, and therefore require an extensive reduction. They form the greater portion of the iron ores of Britain.

The principal varieties of the oxides of iron are,—the magnetic; the massive, found in the north of Europe, and other parts of the world; the micaceous, found in the lava of volcanoes, &c.; and the red and brown hæmatites, found in Great Britain and Europe. The principal varieties of the carbonates are, the massive, found in Great Britain and Ireland, Europe, and America; and also the argillaceous, commonly known as clay iron-stone, found abundantly in beds and coal deposits in England, Wales, and Scotland.

Besides the oxides and carbonates here enumerated, iron is found in large quantities in combination with sulphur; and the several compounds thus formed are known as pyrites, several varieties of which are found in Norway, Sweden, Germany, America, and in many parts of England.

Various artificial oxides of this metal are applied to medicine, dyeing, and other purposes in the arts.

The tenacity and strength of iron are impaired by its adulteration with foreign matters. Thus, of the oxides and carbonates, those are best in which the proportion of the metal is great. These qualities are further increased by fusion, and by the mechanical process of hammering; and this fact points to the main distinction in the kinds of iron as applied for manufacturing purposes, viz. foundry iron, and forge iron.

In the manufacture of iron, the first process is the reduction of the iron-stone or ore, technically called the mine, into the state of a metal. This is done by fusion in a furnace, with coke added to produce com-

bustion, and limestone to act as a flux and assist the fusion of the ore. An artificial current of air is necessary to fuse the ore in these furnaces, which are therefore called blast furnaces, and provided with tubes or tuyères, through the tapered nozzles of which, strong currents of air are delivered to the interior of the furnace, the required velocity of the blasts being sustained by steam or other power. Formerly the air was thus introduced at the same temperature as that of the external atmosphere; but a plan has for many years been extensively adopted of previously heating the air for the blasts in separate vessels to a high temperature, by which the fusion of the ore is so powerfully assisted, that the saving of fuel in the furnace is many times greater than the quantity used for the preparatory heating of the air. Furnaces thus supplied are termed hot-blast furnaces, and the product is called hot-blast iron, while that made with unheated air is called cold-blast iron.

The cost of the process of reduction with the hot blast being so much less than of that with the cold blast, the ultimate value of the former is of course also partly dependent upon the quality of the produce. On this head much difference of opinion has often been manifested, and with all the earnestness usually displayed in the advocacy of self-interest. The value of each process must, no doubt, arise from the completeness of the fusion produced, and the separation effected between the iron and the impurities combined with it in the ore. The hot-blast furnace effects the fusion more readily than the cold-blast, but admits a larger combination of cinders with the ore; and the advantage which has been taken of this facility of adulteration, in order to reduce the cost of production, has doubtless led to the introduction into the market of many qualities of hot-blast iron which are inferior in strength to that made with the cold blast. The results of some of the most carefully conducted experiments which have been made upon the strength of cast iron, and published in the 6th volume of the new series of 'Memoirs of the Literary and Philosophical Society of Manchester,' show that the transverse strength of the cold-blast iron tried was about 2½ per cent. greater than that of the hot-blast. The experiments here referred to were made upon rectangular bars 1 inch square, and 4 feet 6 inches long between the supports. The mean average breaking weights, placed at the middle of these bars, were—

	lbs.
In 21 samples of hot-blast iron	445·5714
In 22 samples of cold-blast iron	456·9090

The metal is allowed to flow from the furnace into rude channels formed on the surface of the ground, where it cools, and is taken up in the form of rough bars about 3 feet long, and each weighing nearly one cwt., which are technically called pigs. In the making of one ton of pig iron in Staffordshire, the following materials are used:

Coal, 2 tons 5 cwt.
If coke is used instead of coal, 1 ton 17 cwt.
Charred mine, or ore, 2 tons 5 cwt. to 2 tons 10 cwt.
Limestone, 13 cwt. to 16 cwt.

In the condition of pig iron, the metal forms the two staple descriptions of foundry iron and of forge iron, according to its qualities, and the proportion of carbon and oxygen which it contains. The several sorts of pig iron are considered to be six in number, and are thus distinguished: Nos. 1, 2, and 3, foundry iron, of which the first two are never used for forge iron. No. 3, or dark grey, and also the fourth quality known as bright iron, are sometimes used for the foundry,

and sometimes for the forge. The fifth and sixth sorts, known as mottled iron and white iron, are never used for the foundry. The order here observed corresponds with that of the proportion of carbon and oxygen mixed with each kind of the iron, and also with that of the fluidity to which the metal is reducible: it also corresponds with the scale of their softness and toughness. Thus, No. 1 has the most carbon and oxygen, and the white iron has the least. No. 1 is the most fluid when melted, and the white iron the least so. Again, No. 1 is the softest, and the white iron the hardest; and No 1 is the toughest, while the white iron is the most brittle. But white iron is the best adapted for conversion into malleable iron, while Nos. 1 and 2, foundry iron, contain so large a proportion of carbon and oxygen, that they are totally unfit to be manufactured into bars.

The conversion of pig iron into malleable iron is effected by extended processes, or subsequent to those by which the ore has been reduced to the form of pig. These processes are as follow:

1. Refining,—2. Puddling, hammering, and rolling,—3. Cutting up, piling, and rolling; the 3rd series of operations being repeated.

The refining is for the purpose of separating a portion of the carbon from the pig, and is performed in furnaces fitted with tuyères for supplying a blast of air to the point of fusion. The metal run from the refining moulds is exceedingly brittle, and is then broken up into small pieces, and committed to the puddling or reverberatory furnace, to undergo a further purification from the oxygen and carbon which remain after the process of refining is accomplished. While in this furnace, the mass into which the pieces of refined metal become clustered is worked and stirred about by the workman or puddler, until its thickness and tenacity are so far increased that it may be formed into lumps, or balls, which the puddler does with tools adapted to the purpose.

The hammering or shingling is performed upon the balls or blooms of puddled iron, with a very heavy hammer, worked by a cam-wheel, and has the effect of improving the solidity of the metal, and reducing the balls into an oblong form, by which they are better prepared for the action of the rollers.

The rolls or rollers are fitted together in pairs, and so formed in the periphery and arranged in size, that open spaces are formed between them, through which the metal is passed while hot; and each succeeding pair of rollers presenting a smaller space, the iron which is drawn through them becomes proportionately reduced in size and increased in length.

The metal has thus been converted from a hard brittle and readily fusible substance into a malleable bar, which is soft, tough, and very difficult of fusion; but it is still far from fit for the smith's use, being to a great extent unsound in structure, imperfect in tenacity, and irregular on the surface.

The third set of processes is now commenced by cutting up the puddled bars into lengths with powerful shears. These lengths, of various dimensions, according to the sized bars to be produced, are carefully piled up and heated in another furnace similar to the puddling furnace, and which is called the balling furnace. In this the bars are simply heated to a degree which admits of their becoming welded together in the pile and adapted for reduction to the form of finished bars in the rolls.

The rolling is the last operation in the making of bar-iron. The metal is drawn successively through a series of rollers, that is, between

the peripheries of each pair of rollers, and thus gradually reduced in size, increased in length, and freed from the cinder and other impurities which remain after the puddle-rolling has been performed.

The last set of operations is sometimes repeated in producing iron for superior purposes. The processes here described will give a general idea of the manufacture of iron from the native ore into the form of malleable bars; and it may be readily conceived how an extension and variation of the process of rolling may be made to produce the several other forms in which this metal is prepared for the constructions of the engineer, the smith, and the machinist.

As varieties of bar-iron may be mentioned,—L, or angle-iron; T, or tee-iron; and H, or deck-beam iron; which are prepared in several sizes, for the construction of roofs, iron vessels, &c. The malleable rails used for railways are also produced by an arrangement of rollers.

Boiler-plate iron, sheet-iron, hoop-iron and nail rod-iron, are produced from the form of bars by the processes of heating and rolling, or hammering, as required. Boiler-plates require, according to the desired strength and size, several repetitions of heating, hammering, and rolling. Sheet-iron is distinguished from boiler-plate by being thinner; hoop-iron is rolled in the same manner as the bars, but between rollers without grooves in their edges, the requisite thickness being effected by successive passages through the rollers, which are brought nearer to each other at each process, by means of adjusting screws. Nail rod-iron is rolled in thin bars, which are, while still hot, passed between steel-cutters that slit them up into the form of small rods, which, although rough, are well fitted to be manufactured into nails.

A very useful form of sheet-iron, which should be noticed, is that of corrugated iron, which is produced by passing the sheets between rollers having grooved peripheries. By this form, the strength or stiffness of the sheet is so much increased, that sheet-iron thus formed may be usefully applied to a great variety of purposes, for which it is otherwise, owing to its thinness and pliability, utterly inadequate.

By the combustion of charcoal with the coke, and the adaptation of a peculiar furnace in the process of smelting, Mr. Clay has succeeded in producing malleable iron direct from the ore, and thus materially reducing the series of processes here described. The results thus brought out are of a very interesting character, and promise to acquire a great practical value.

Iron. Moses forbade the Hebrews the use of any stones to form the altar of the Lord, which had been in any manner wrought with iron; as if iron communicated pollution. He says, the stones of Palestine are of iron, that is, of hardness equal to iron, or, being smelted, they yielded iron. "An iron yoke" is a hard and insupportable dominion. "Iron sharpeneth iron," says the Wise Man; "so a man sharpeneth the countenance of his friend:" the presence of a friend gives us more confidence and assurance. God threatens his ungrateful and perfidious people with making the *heavens iron*, and the earth brass; that is, to make the earth barren, and the air to produce no rain. Chariots of iron are chariots armed with iron, with spikes and scythes.

Iron-stone, iron-bound stone, in colour of a blueish gray, and very hard to work: it contains but very little iron

Iron-stone has the appearance of rusty black shale, and, when laid together in large heaps, is so combustible that it ignites, leaving a a calx of 60 per cent. of iron. It

abounds in Scotland. Common iron-stone is also very abundant in connection with coal, and in former times formed the principal supply, which induced the foundation of the Carron Iron Works.

Iron wood is imported from the Brazils, the East and West Indies, and other countries, in square and round logs, 6 to 9 inches and upwards through. Its colours are very dark browns and reds: sometimes it is streaked, and generally straight-grained: used principally for ramrods, turnery, &c., and is extremely hard.

Iron yellow, jaune de fer, or jaune de Mars, &c., is a bright iron ochre, prepared artificially, of the nature of sienna earth. The colours of iron exist in endless variety in nature, and are capable of the same variation by art, from sienna yellow, through orange and red, to purple, brown, and black, among which are useful and valuable distinctions, which are brighter and purer than native ochres.

Isochronism, in mechanics, the performing of several things in equal times; such as the vibrations of the pendulum

Isodomon, a building every way straight

Isodomos, in Greek architecture, masonry cut and squared to the same height, so that, when laid, the courses were all regular and equal

Isometrical, projections and drawings so termed

Isoperimetrical, in geometry, such figures as have equal perimeters or circumferences

Isosceles, in geometry, a triangle that has only two sides equal

Isothermal, in chemistry, equal heat

Italian Architecture, a style now much appreciated not only in Italy, but in England and France, was first introduced at the revival of classical architecture, and was subsequently much improved and adapted to modern refinement. The architecture of Venice, Florence, Genoa, Rome, and Sicily, afford to the architect a complete library of examples, by the possession of the several works published of the architecture of the palaces and mansions of these cities.

Italian Architecture, Roman. Respecting buildings originally erected in Italy Mr. Jos. Gwilt has thus written:

The Romans followed the Greeks in the general form of their temples, but added to their splendour by a greater richness of detail, and the employment of other orders. For the simple steps on which the Greek temple was elevated, they substituted pedestals, and added a base to the Doric order. The climate prescribed a more elevated pediment; but the luxury of the people was the cause of the preference given to the richer orders of architecture.

TEMPLES, BRIDGES, AQUEDUCTS, COLUMNS, THEATRES, &c.

The chief temples of Rome were —the Capitol, built on the Tarpeian or Capitoline mount, by Tarquinius Superbus. (See *Capitolium.*) No traces of it at present remain. The edifice of the Capitol was about 200 feet square, and contained three temples, consecrated to Jupiter, Minerva, and Juno. On the Capitol were also the temples of Terminus and Jupiter Feretrius, and the cottage of Romulus.

The Pantheon, built by Agrippa, the son-in-law of Augustus, and dedicated to Mars and Venus, or more probably, from its name, to all the gods. Pope Boniface IV. consecrated it in honour of the Virgin Mary and All Saints, A.D. 607. It is now generally known by the name of the 'Rotonda;'—its diameter between the axes of the columns is 147 feet: like most of the ancient buildings, it has fallen a prey to the spoiler. The Baldachino in St. Peter's is indebted for its materials to the Pantheon of Agrippa.

The temple of Apollo, on the Palatine hill, was built by Augus.

tus: a temple of Diana stood on the Aventine.

The temple of Janus was supposed to have been built by Romulus; that of Romulus by Papirius. Of those to the Sun and Moon, Fortuna Virilis, Vesta, Minerva Medica, Neptune, Antoninus and Faustina, Concord, Jupiter Stator, and most particularly of the temple of Peace, considerable remains are fortunately still in being. The three magnificent arches now standing of that last named, though of themselves majestic, convey but a faint idea of its pristine splendour. Of the temple of Jupiter Stator, whose columns, capitals, and entablatures were a perfect example of the Corinthian order, only three columns are in existence. The remains of the temples of Antoninus Pius, Claudius, Hercules, Jupiter Tonans, Isis, Romulus, and Venus and Cupid, are still interesting.

No vestiges exist of the temples dedicated to Saturn, Juno, Mars bis Ultor, in the forum of Augustus, nor of numberless others that adorned the city.

The temples of Balbec and Palmyra are the last of the ancient Roman works that can lay claim to the appellation of classic architecture. In these, invention seems to have found its limits. The reproduction and new adaptation of their detail was all that has been done by following artists.

The Romans, not content with the quadrilateral temple, made use of the circular form, as in the Pantheon, temple of Vesta, and others at Rome, and that of the Sibyl at Tivoli. Except their theatres, and the little work generally known by the name of the Lantern of Demosthenes, the Greeks have left no buildings on a circular plan.

After the time of Diocletian, a new style prevailed in Italy. The basilicæ of Constantine, as they existed previous to their restoration, and, in short, almost all the first Christian churches, were built out of the materials which the old temples afforded in abundance. The basilica of S. Paolo fuori le murà still contains a large portion of the columns which had originally belonged to the mausoleum of Adrian. The style of these basilicæ may with propriety be termed Roman-Gothic. This was followed by the Greek-Gothic, of which examples may be found in most of the cities of Italy, as in St. Mark at Venice, the cathedral at Pisa, (built by Buschetto da Dulichio, a Greek architect of the 11th century,) and in the baptistery and leaning campanile of the same city: specimens abound also in Bologna, Sienna, Venice, Viterbo, Rome, &c. They are chiefly the works of Nicola da Pisa and his scholars.

At the time that the famous cathedral of Milan, the perfection of the Lombard-Gothic style, was in hand, Brunelleschi was advancing a step further, and had begun the restoration of classical architecture in the great cupola of Sta Maria del Fiore at Florence; his prototype seeming to have been the temple of Minerva Medica, to which his work has sufficient resemblance to justify the allusion to it. He succeeded in his enterprise, and thus gave a death-blow to the Italian-Gothic of all sorts. L. B. Alberti, Bramante, and Fra. Giocondo restored the use of the orders; Michael Angelo, Raphael, Sangallo, Palladio, and Scamozzi completed the change; the church of St. Peter rose, and every little city began to provide itself with a Duomo.

The fora of the ancients were large squares surrounded by porticoes, which were applied to different purposes. Some parts of them answered for market-places, other parts for the public meetings of the inhabitants, still other parts for courts of justice. The forum also occasionally afforded accommodation for the shows of gladi-

ators. Rome contained seventeen fora, of which fourteen were used for the show and sale of goods, provisions, and merchandise, and were called Fora Venalia; the other three were appropriated for civil and judicial proceedings, and hence called Fora Civilia et Judicialia. Of the latter sort was the forum of Trajan.

The forum of Julius Cæsar was far more splendid than the Forum Romanum: it cost upwards of £800,000 sterling, and stood in the neighbourhood of the Campo Vaccino, to the east of the temples of Peace and of Antoninus and Faustina.

In the vicinity of that last named was the forum of Augustus: the temple of Mars bis Ultor decorated the centre of it.

The forum of Nerva, called also the Forum Transitorium, begun by Domitian, was decorated by Alexander Severus with colossal statues of the emperors, some of which were equestrian. Parts of this forum are still in tolerable preservation.

The forum of Trajan, which has lately been accurately traced by means of very extensive excavations, and the demolition of a great number of houses, was by far the most magnificent. The Trajan column formed one of its ornaments: the architect was Apollodorus, and its situation was between the forum of Nerva and the Capitol.

The basilica (a term now applied to the cathedrals of Rome) was originally a court of justice. Like the forum, it was furnished with shops for the merchants and bankers. In the place called the Comitium were four basilicæ, viz. that of Paulus, the Basilica Opimia, Julia (built by Vitruvius), and Portia: besides these, the most important were those of Sicinius, Sempronius, Caius and Lucius, Antoninus Pius, and the Basilica Argentariorum, or of the goldsmiths. Some of less consideration stood in the vicinity of the Forum Romanum.

The modern halls of Italy in some respects answer the purpose of the ancient basilicæ. Those most worthy of notice are at Venice, Vicenza, Padua, and Brescia.

Near the Tarpeian rock stood the famous prison built by Ancus Martius, which was afterwards called Tulliana, from the additions thereto by Servius Tullius. The Curia Hostilia, where the senate frequently met, was the Comitium: at its entrance, close to the temple of Saturn, was the Milliarium Aureum, the central point from which all the roads to the different provinces diverged, and near to which ran the gallery constructed by Caligula, which joined the Palatine and Capitoline hills. It was constructed with eighty columns of white marble.

The porticoes of Pompey, Augustus, Domitian, and Nero were the most celebrated of Rome. The first-named afforded a refreshing retreat from the sun's rays. The portico of Augustus was constructed with columns of African marble, and was ornamented with fifty statues of the Danaides.

Those of Nero, three in number, each three miles in length, were called Milliariæ, on account of their extraordinary dimensions, forming a part of his palace.

The pyramidal form was generally applied to tombs. In the heroic ages, a cone of earth, whose base was of considerable extent, covered the ashes of the person to be commemorated. This was the practice of the early ages. Men were, however, desirous of triumphing over death, and the Pyramids, as well as numberless other monuments, the names of whose authors are now lost, have proved the vanity of their desires: the memory of man must depend upon "deeds done in the flesh."

The pyramid of Caius Cestius, a trifle compared with those of Egypt, is yet enormous, considering the individual to whose memory it was erected. The tower of Cecilia Metella, called the Capo di Bove, on the Appian way, is a beautiful specimen of art. The Appian, Flaminian, and Latin ways exhibit numberless sepulchres of an interesting nature. Those which are found with the inscription D. M., or Diis Manibus, contain the ashes of the persons whose names they bear; but the others are mostly cenotaphs, the bodies having been deposited elsewhere.

Triumphal arches may be reckoned among the luxuries of the Romans. Nothing which could tend to perpetuate the fame of the conqueror was omitted in the design. Some of them were with two, some with three passages. The richest were on the Triumphal way. Those which also served as gates generally consisted of two openings, one for the carriages passing out of, the other for carriages passing into the city. With the Greeks, a trophy erected on the field of battle was held of equal importance with the triumphal arch of the Romans, and a breach was sometimes made in the walls to admit the entry of the conqueror.

The Roman senate received the conqueror at the Porta Capena, near the Tiber, which was the entrance to the city from the Appian way.

The arch of Augustus at Rimini has but a single passage, about 33 feet wide: it was crowned with a pediment, contrary to the usual practice. This was a beautiful specimen, but it is much mutilated.

That called the arch of the Goldsmiths at Rome is a curious example. It is very small, with a single opening, whose crowning is a flat lintel.

The arch of Augustus at Susa, a small town just on the Italian side of Mount Cenis, is extremely elegant. Those of Aurelian and Janus are more singular than beautiful.

The arch of Pola in Istria is only curious on account of its affording a justification of the use of coupled columns, were the authority of the ancients necessary for the purpose: it was erected by Salvia Posthuma in honour of Sergius Lepidus and his two brothers.

The arch of Trajan at Ancona is still in tolerable preservation. It has long since been stripped of its bronze ornaments, but their absence has not impaired its elegant proportions.

The arches of Titus at Rome and Trajan at Benevento bear considerable resemblance to each other. That of Gavius at Verona, called 'del Castel Vecchio,' no longer exists. The precepts of Vitruvius have been confronted with his practice in this arch; but Vitruvius Cerdo, not Vitruvius Pollio, was the architect.

The arches of Septimius Severus and of Constantine are with three openings. The latter is decorated with ornaments shamefully stripped off from the arch of Trajan, which, from their absurd application, render the barbarism of the robber more disgusting.

Rome formerly contained eight bridges. The Pons Sublicius, built by Ancus Martius near the Tiber, was of timber, so framed as to require no iron bolts or ties for its security. It stood at the foot of the Aventine, and was that which Horatius Cocles defended. It was replaced by one of stone by Æmilius Lepidus, and then had the name of Æmilianus. Tiberius afterwards repaired it. Finally, Antoninus Pius rebuilt it of marble, whence it obtained the name of Marmoratus.

The Pons Triumphalis, near the Vatican, is in ruins: few vestiges of it exist. Those who triumphed passed over this bridge in their way to the Capitol.

The Pons Fabricius led to an

island in the Tiber: it is now called Quattro Capi. That which led from the island to the right bank of the river was called Pons Cestius or Esquilinus: it was rebuilt during the reigns of the emperors Valentinian, Valens, and Gratian.

Pons Janiculi, so called because it led to the Janiculum, and now known by the name of Ponte Sisto, (from having been restored by Sixtus IV.) was of marble, and built by Antoninus Pius.

Pons Ælius, built by Ælius Adrianus, is still in existence. It is situated close to the mausoleum of Adrian. This having changed its name into that of Castel St. Angelo, the bridge has acquired a corresponding appellation.

The Pons Milvius, now Ponte Molle, is a little way out of the city, on the road to Florence. On this bridge Cicero arrested the ambassadors of the Allobroges, and in its vicinity Constantine defeated Maxentius.

Pons Senatorius, or Palatinus, is partly remaining, close to the Patine mount.

Ponte Salaro is over the Teverone, about three miles from Rome.

The spans of the arches are generally but small; yet there are some few magnificent exceptions, as in the Ponte del Castel Vecchio at Verona. This consists of three arches, the largest of which is 170 feet span; its two other arches are smaller: they diminish from the city, the left bank of the river being considerably lower than the right. The bridge built by Augustus over the Nar, near Narni, on the Flaminian way, was a single arch of 150 feet span. In the later times of the city, bridges were decorated with trophies, colossal statues, triumphal arches, and the like. Such was the case with the Pons Ælius and the bridge of Augustus at Rimini.

The country round Rome is covered with the remains of aqueducts, some of which conveyed the water to Rome from a distance of more than 60 miles.

The first aqueduct (Aqua Appia) was built, according to Diodorus, by Appius Claudius, in the year of the city 441. The water which it supplied was collected from the neighbourhood of Frascati, and its summit was about 100 feet above the level of Rome.

The second (Anio Vetus) was begun forty years after the last-named by M. Curius Dentatus, and finished by Fulvius Flaccus: it was supplied from the country beyond Tivoli. Near Vicovaro it is cut through a rock upwards of a mile in length, in which part it is 5 feet high and 4 feet wide. The water of this aqueduct was not good, and therefore only used for the most ordinary purposes.

The third (Aqua Martia) was supplied from a fountain at the extremity of the mountains of the Peligni. The water entered the city by the Esquiline gate. This aqueduct was the work of Quintus Martius.

The fourth (Aqua Tepula) was supplied from the vicinity of Frascati.

The fifth (Aqua Julia) was about six miles long, and entered the city near the Porta Esquilina.

The sixth (Aqua Virginis) was constructed by Agrippa thirteen years after that immediately preceding. Its summit, in the territory of Tusculum, was about eight miles from Rome, which it entered by the Pincian gate. This water still bears its ancient appellation, being called Aqua Vergine.

The seventh (Aqua Alsietina, called also Augusta, from the use to which Augustus intended to apply it for supplying his Naumachia,) was brought from the lake whose name it bears.

The eighth (Aqua Claudia), whose summit is about forty miles from Rome, was begun by Caligula, and completed by Claudius. It enters

the city at the Porta Nevia, near the Esquiline mount. The quality of the water which this aqueduct supplies is better than that of any of the others.

The ninth (Anio novus, to distinguish it from the second-named water,) was begun and finished by the same persons as the last mentioned. It is the water of the Anio, which, being exceedingly thick and muddy after the rains, is conveyed into a large reservoir at some little distance from Rome, to allow the mud to subside.

The Aqua Felice is modern, and was erected by Sixtus V. in 1581.

The popes have, from time to time, been at considerable pains and expense in repairing and renewing the aqueducts; but the quantity of water delivered is constantly diminishing. In the ancient city, the total sum of the areas of the different pipes (which were about an inch in diameter) through which the above immense quantity of water was delivered, amounted to about 14,900 superficial inches; but the supply was subsequently reduced to 1170.

The waters were collected in reservoirs called *castella*, and thence were conveyed through the city in leaden pipes. The keepers of the reservoirs were called *castellani*. Agrippa alone built thirty of these reservoirs during his ædileship. There are five modern ones now standing in the city: one at the Porta Maggiore, Castello dell' Acqua Giulia, dell' Acqua Felice, dell' Acqua Paolina, and that called the Fountain of Trevi.

In later times, the bath was always used by the Romans before they went to their supper. The rich generally had hot and cold baths in their own houses; and it was not till the time of Augustus that the baths assumed an air of grandeur and magnificence. They were called Thermæ, that is, hot baths, though the same pile of building always contained cold as well as hot baths. Different authors have reckoned as many as 800 public baths in Rome. The chief were those of Agrippa, Nero, Titus, Domitian, Caracalla, Antoninus, and Diocletian. Their vestiges indicate the amazing magnificence of the age in which they were erected. The pavements were mosaic, the vaulted ceilings were gilt and painted, and the walls incrusted with the richest marbles. Some of the finest and best preserved remains of ancient Greek sculpture have been restored to light from these edifices. It was from these that Raphael took the hint for his fantastic decorations of the Vatican, and the first restorers of art drew their resources.

Dramatic entertainments were first introduced at Rome in the 391st year of the city. In ancient times the people stood during the performance. For a considerable period the theatres were mere temporary buildings constructed of wood. The most splendid of these upon record was that of Marcus Æmilius Scaurus: it was magnificently decorated, and was capable of containing 80,000 persons.

It was in Pompey's second consulship that the first stone theatre was erected: this accommodated 40,000 spectators. To avoid the animadversions of the censors, (for the magistracy did not yet sanction theatrical exhibitions,) he dedicated it to Venus.

Several other theatres afterwards arose: that of Marcellus can still be distinctly traced, and part of the circular façade, in tolerable preservation, is singularly elegant. The theatre of Balbus was also of considerable celebrity.

The theatres were open at top to the heavens; but in times of rain or excessive heat, means were provided for covering them with a species of cloth awning, by which the inclemency of the weather might

be wholly or partially excluded. Their general form on the plan was that of the letter D. The seats (*gradus*) rose behind each other, like steps. The front row was assigned for the use of the senators and the ambassadors of foreign states. Fourteen rows behind this were reserved for the equites, and the rest were open for the public generally. The beautiful Olympic theatre, by Palladio, at Vicenza, was formed on the model of the ancient Roman theatres, and gives one an excellent idea of their effect.

Like the theatres, amphitheatres were at first constructed of wood, and were only temporary. The first amphitheatre of stone was built by Statilius Taurus, at the desire of Augustus.

Of all the monuments of antiquity, none is capable of creating such sublime sensations in the mind as the stupendous amphitheatre generally called the Coliseum. It was commenced in the time of Vespasian, and completed by Titus. The plan of it is oval, and its accommodation was for 87,000 spectators, who could enjoy the exhibitions therein without crowding each other.

That part in which the gladiators fought was at the bottom, and was called the arena, from being usually covered with sand to absorb the blood spilt in the savage conflicts for which it was used. The arena was encircled by a wall, called the podium, which projected at top. The podium was fifteen or sixteen feet in height: immediately round it sat the senators and foreign ambassadors. As in the theatres, the seats rose at the back of each other: fourteen rows in the rear of the podium being allotted to the equites, and the remainder to the public generally, who sat on the bare stone; but cushions were provided for the senators and equites. Though open to the sky, the building was occasionally covered by means similar to those used in the theatres.

The amphitheatre at Verona is still in excellent preservation.

The Naumachiæ, or buildings for the exhibition of sham naval combats, were somewhat similar on their plans to the circi, to which purpose also sometimes these latter were appropriated. The amphitheatres were, moreover, occasionally used for the same sort of display.

Those of Augustus and Domitian were the most magnificent.

The circus was a long narrow building, whose length to its breadth was generally as five to one: it was divided down the centre by an ornamented barrier, called the *spina*. These buildings were used for the celebration of games, racing, &c.; and sometimes also for making harangues to the people.

The first circus of stone is attributed to Tarquin, and was situated between the Palatine and Aventine mounts.

The Circus Maximus was much improved and altered by Julius Cæsar, who supplied it with water for the purpose of occasionally using it as a naumachia. Augustus made great additions to it, decorating it with the famous obelisk which now stands in the Piazza del Popolo, where it was placed by Fontana in the year 1589, during the pontificate of Sixtus V. Being much dilapidated, it was repaired under Antoninus, and afterwards embellished with a second obelisk, which has found a resting-place in front of the church of St. John Lateran, where it was set up by the same Fontana. No vestiges of this circus remain.

The circus of Flaminius, in the vicinity of the Pantheon of Agrippa, was of considerable dimensions, and very magnificent.

The Circus Agonalis occupied the site of what is now known by the name of the Piazza Navona.

The circus of Nero, upon a part

whereof some portion of the basilica of St. Peter is seated, was a splendid building. The obelisk now standing in the open circular piazza before St. Peter's belonged to this circus.

Those of Florus, Antoninus, and Aurelian, are no longer even in ruins; but that of Caracalla is sufficiently perfect to trace its plan and distribution. It was 738 feet in length.

The streets, in the time of Augustus, were narrow and irregular. After the great fire in Nero's reign, the city was rebuilt with greater splendour. The streets were then set out straight, and considerably broader than before. Those houses wherein several families dwelt were called *insulæ*. *Domus* was the expression of a house occupied by one family only.

We know little of the form of the Roman houses, though Vitruvius has described at sufficient length the different apartments of which they consisted.

The small houses discovered in the ruins of Pompeii can bear but little if any resemblance to the houses of the opulent inhabitants of Rome. The most celebrated were those of the Gordians, P. Valerius Publicola, Cæsar, Sallust, Mecænas, Cicero, Verres, Augustus, and Lucullus. The Domus aurea of Nero was probably the most magnificent in Rome. The villa of Adrian, at Tivoli, was so extensive, that it almost deserved the name of a city. Immense ruins of the palaces of the Cæsars are still to be seen.

Rome was decorated with numberless pillars. The most remarkable are fortunately in an excellent state of preservation, namely, those of Trajan and Antoninus.

The column of Trajan stood in that emperor's forum: it is about 12 feet in diameter at its base, and (including the pedestal) is about 125 feet in height. The ascent to the gallery on the top of the abacus of its capital is by 185 steps, each 2 feet 9 inches long, winding round the column, and lighted by 40 openings. A colossal statue of Trajan formerly crowned the top; but St. Peter has long since deposed the emperor.

The column of Antoninus is 176 feet high, its number of steps 106, with 56 openings for the admission of light. Sixtus V. caused its pedestal to be cased, when, in 1589, the pillar was under repair. It was this pontiff who elevated St. Peter to his situation, as well on this as on the Trajan column.

The great sewers of Rome are reputed to have been the work of Tarquinius Priscus. The Cloaca Maxima, which still carries some of the filth and waste water of Rome into the Tiber, was the work of Tarquinius Superbus.

The public ways were not only some of the most stupendous, but also the most useful of the Roman works.

The first road which the Romans paved was the Via Appia, so called because it was executed by order of Appius Claudius. He carried it as far as Capua, whence it was afterwards continued to Brundusium —in all, a distance of 350 miles. It is still entire in many places, though more than twenty centuries have elapsed since its construction. It was properly called 'Regina Viarum.'

The Via Numicia led to Brindis (Brundusium); the Via Flaminia to Rimini and Aquileia; the Via Aurelia was along the coast of Etruria; the Via Cassia ran to Modena, between the Flaminian and Aurelian ways; the Via Æmilia extended from Rimini to Piacenza.

The smaller ways were, the Via Prænestina to Palestrina (the ancient Præneste); Tiburtina to Tivoli; Ostiensis to Ostia; Laurentina to Laurentum, south of Ostia; Salaria, &c. The cross-roads were called Diverticula.

Italian architecture comprises so many diversities that it is hardly possible to affix to it any thing like a precise character, except by limiting it to a particular epoch or school, or to one special class of buildings; and even then the exceptions may be more numerous than the examples referred to as a standard. With many vices and defects, it possesses many excellences and recommendations, and a variety of resources, which render it capable of being turned to far greater account than hitherto has been done. But if on the one hand it affords much scope to the architect, it calls on the other for the exercise of discriminating taste; one that not only rejects what is positively bad, but is capable of re-combining all the better elements of the style, so as to impart to them originality and freshness, without forfeiting what is valuable in and characteristic of the style itself; so that, instead of appearing contrary to its genius, the novel forms and effects that may be produced shall seem to be beauties, which have merely been lying latent, and waiting for a discoverer to bring them to light. A style is to be judged of, not only retrospectively by what it has produced, but prospectively also, according to what it is capable of supplying. Nevertheless, so far from being at all encouraged, such view of the subject is kept out of sight as much as possible; and precedent is allowed to usurp such sway, that any departure from it, no matter in what spirit, is liable to be confounded with and reprobated as capricious innovation, although the one proceeds quite in an opposite direction to the other.

Italian church (the), in the front or façade, is never true to the internal structure; it is always divided into two apparent stories, by two heights of pillars, or pilasters, and by windows, or alcoves; but the greater number of churches in Rome have the outward look of large dwelling-houses, a highly ornamented centre and wings less so, with two or three ranges of windows, not differing from a habitable house

Ivory is first mentioned in the reign of Solomon: ivory was used in decorating those boxes of perfumes whose odours were employed to exhilarate the king's spirits. It is probable that Solomon, who traded in India, first brought thence elephants and ivory into Judea. Cabinets and wardrobes were ornamented with ivory by marquetry-work. These were called 'houses of ivory.'—"Eighty more chests of ivory, for your use and pleasure," are enumerated in the letter which accompanied the very remarkable tribute of the Ethiopian queen, Candace, to Alexander the Great.

Ivory-black and *bone-black*, ivory and bone charred to blackness by strong heat in closed vessels; if skilfully prepared, they are eligible for oil and water painting

JAC JAM

Jack, an instrument for raising a heavy weight through a short distance; it consists of a strong piece of wood, with an iron rack which is moved, by wheels fixed inside the wood, from a handle outside

Jack, in navigation, a flag or colour; *a small union flag*

Jak wood, a native of India, is imported in logs from 3 ft. to 5 ft. diameter; the grain is coarse and crooked: used in cabinet-work, marquetry, and turning, and also for brush-backs

Jamb, in building, a supporter on either side, as the posts of a door

Jambs, the side pieces of any opening in a wall, which bear the piece that discharges the superincumbent weight of such wall

Janta, a machine extensively used in Bengal and other parts of India, to raise water for the irrigation of land. It consists of a hollow trough of wood, about 15 ft. long, 6 inches wide, and 10 inches deep, and is placed on a horizontal beam lying on bamboos fixed in the bank of a pond or river: one end of the trough rests upon the bank, where a gutter is prepared to carry off the water, and the other end is dipped in the water by a man standing on a stage, plunging it in with his foot.

Janua, among the Romans, the street-door of a private house

Japanning, the art of painting and varnishing on wood, leather, metal, or paper, after the manner of the Japanese

Jaune Minérale. This pigment is a chromate of lead, prepared in Paris. The chrome-yellows have obtained other names from places or persons from whence they have been brought, or by whom they have been prepared, such as Jaune de Cologne, &c.

Jesse (the root of), a term applicable to the genealogy of Christ, as affording subjects for the painter, sculptor, or embroiderer

Jet d'Eau, a French expression, signifying a fountain that throws up water to some height in the air

Jetty, a part of a building that projects beyond the rest, and overhangs the wall below, as the upper stories of timber-houses, bay-windows, pent-houses, small turrets at the corners, &c.

Jetty, a projecting erection into the sea, partaking something of a pier, mostly constructed of timber, with open spaces for the sea to play

Jewry, a district, street, or place or locality, in which Jews formerly resided

Jib, the overhanging part of a crane, or a triangular frame with a pulley at the end, for the chain to pass over which leads from the crane

Jib, in navigation, the foremost sail of a ship

Jib-boom, a spar run out from the bowsprit

Jigger, a machine consisting of a piece of rope about 5 feet long, with a block at one end and a sheaf at the other, used to hold on the cable when it is heaved into the ship by the revolution of the windlass

Jigging, in Cornwall, a method of dressing the smaller copper and lead ores, by the motion of a wire sieve in a kieve or vat of water

Joggle, a term in the business of masonry, the art of joining and fitting the stones together

Joinery, the art of joining, comprehends all the fixed wood-work intended for ornament or convenience in the interior of a house

Joint, the interstices between the stones or bricks in masonry and brick-work are so called

Joists, in carpentry, the secondary beams of a floor; those pieces of timber framed into girders and summers, on which the boards of the floor are laid

Journal, a bearing of a shaft when it is between the points where the powers and resistance are applied; a bearing subject to torsion

Jube, anciently, the rood-loft or gallery over the entrance into the choir of a cathedral or church

Jugumentum, the lentil of a door

Jumper, a long borer used by one person

Jumper wood, an aromatic and very durable kind of wood

Junk-ring, a ring fitting a groove round a piston, to make it steam-tight. The ring is turned accurately to the diameter of the cylinder, and slightly hammered all round on the inside to increase its elasticity; it is then cut open, and put in its place: springs are sometimes used for pressing it outward.

Justice (*Courts of*). These places (according to Palladio) were anciently called basilicæ, where the judges attended to administer justice, and where, sometimes, great and important affairs were trans-

acted: whence we read, that the tribunes of the people caused to be taken away a column that interrupted their benches, from the Basilica Portia; which was at Rome, near the temple of Romulus and Remus, and is now the church of St. Cosmus and Damianus.

KAG

KAGE, anciently applied to chantry chapels enclosed with lattices or screen-work

Kaolin, aluminous earth; the porcelain earth of the Chinese

Kazer, in Cornwall, a sieve

Kedging, in navigation, a term used when a vessel is brought up or down a narrow river or over a bar

Keel, false, in ship-building, a strong thick piece of timber bolted to the bottom of the real keel, which is very useful in preserving it

Keels, in navigation, small vessels that carry coals down the river Tyne

Keelson, in ship-building, the piece of timber attached to a ship's keel

Keep, the chief tower or dungeon of a Norman castle

Keeping, in painting, is the observance of a due proportion in the general light and colouring of a picture, so that no part be too vivid or more glaring than another, but a proper harmony and gradation be evident in the whole performance

Kept down is a term implying gloominess of tint, or an object so shaded with fuscous colour that its form can scarcely be determined; which object is not intended to be seen by the spectator until he has regularly observed all the other parts of the painting, but which is necessary to the composition

Kermes lake, an ancient pigment, perhaps the earliest of the European lakes: the name is probably derived from the alkermes of the Arabians, from Kerman, the ancient Carmania, on the borders of Persia

Kerned, a term applied to a heap of mundic or copper ore hardened by lying exposed to the sun

Ketch, in navigation, a vessel with with masts and sails

Kevels, in ship-building, answer the

KIN

purpose of timber-heads, and are sometimes fixed to the spirketing on the quarter-deck, when the timber-heads are deficient

Key, a term applied to a painting when one object, generally the principal one, is so worked up to its proper tone, strength of colour, &c., that the painter is compelled to finish the whole piece in a masterly manner: this is said to have been the practice of Titian

Key-grooving machine, a machine for cutting the grooves or key-ways in the boss of a wheel to be fixed on a shaft

Key-screw, a lever used for turning screws

Key-stone, the stone in an arch which is equally distant from its springing extremities. In a circular arch there will be two key-stones, one at the summit and the other at the bottom thereof: in semi-circular, semi-elliptical arches, &c., it is the highest stone, frequently sculptured on the face and return sides.

Kiabooca wood, or *Amboyna wood*, imported from Sincapore, is very ornamental, and is used for small boxes and writing-desks, and other ornamental works

Kibbal, a bucket in which ore is raised from the mines

Kieve, a vat or large iron-bound tub for washing of ores

Kilkenny marble, a fine black marble, full of shells and corolloid bodies

Killas, a clay slate occurring in different parts of a mine

Killepe, anciently a gutter, groove, or channel

Kilogramme (pronounced *Kilo*), a French weight, equivalent to 2 lbs. 3 oz. 5 drs. 13 grs. avoirdupois

King-at-arms, in heraldry, a principal

officer at arms, of whom there are three: Garter, Norroy, and Clarencieux

King-post, the middle post of a roof, standing in the tie-beam and reaching up to the ridge; it is often formed into an octagonal column with capital and base, and small struts or braces, which are slightly curved, spreading from it above the capital to some other timbers

Kingston's valve, a flat valve forming the outlet of the blow-off pipe of a marine engine: it opens from the side of the vessel by turning a screw

King wood, called also *violet wood*, is imported from the Brazils: it has violet-streaked tints, and is used in turnery and small cabinet-work

Kirk, church, a term still used in Scotland, formerly so in England

Klinometer, or *Clinometer*, an instrument contrived to measure the inclinations of stratified rocks, the declivity of mountains, and the dip of mineral strata

Knee, a term sometimes used for the return of the drip-stone at the spring of an arch

Knees, in ship-building, are the crooked pieces of oak timber, or iron, which secure the beams to the side of the ship

Knight-heads or *bollard-timbers*, the timbers on each side nearest the stern, and continued high enough to secure the bowsprit

Knits, small particles of lead ore

Knockings, lead ore with spar, as cut from the veins

Knot or *Knob*, a boss; a round bunch of leaves or flowers, or other ornament of a similar kind

Knuckle-timber, the foremost top timber in the ship that forms the buck-head; the timbers abaft it, as far as the angle is continued, may be called knuckle-timbers

Krems, *Crems*, or *Kremnitz white*, a white carbonate of lead, named from Crems or Krems, in Austria; also called Vienna white

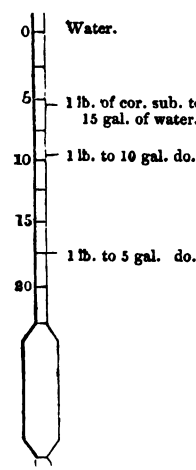
Kyanizing and *Burnettizing*. Kyanizing is a simple process by means of which timber, canvas, and cordage, &c. may be preserved from the effect of dry-rot, and seasoned in a very short time. It was invented by Mr. Kyan, who obtained a patent for it, which was purchased by a company called the 'Anti-Dry-rot Company,' constituted and empowered by Act of Parliament.

The timber is prepared as follows: a wooden tank is put together so that no metal of any kind can come in contact with the solution when the tank is charged.

The solution consists of corrosive sublimate and water, in the proportion of 1 lb. of corrosive sublimate to 10 gallons of water as a maximum strength, and 1 lb. to 15 gallons as a minimum, according to the porosity or absorption of the timber subjected to the process.

Oak and fir timber absorb nearly alike, but the domestic woods, such as beech, poplar, elm, &c. are more porous.

An hydrometer will mark accurately the strength of the solution, water being 0° (*vide* diagram); then, when the hydrometer sinks to 6°,



it denotes that the solution contains 1 lb. of sublimate to 15 gallons of water; when it rises to 17°, 1 lb. of sublimate to 5 gallons.

As a general rule, when it stands midway between 5° and 10°, the solution will be the proper strength.

The corrosive sublimate will dissolve best in tepid water.

The period required for saturating timber depends on its thickness: 24 hours are required for each inch in thickness, for boards and small timbers.

The timbers, after saturation, should be placed under a shed or cover from the sun and rain, to dry gradually.

In about 14 days, deals and timber not exceeding 3 inches in thickness will be perfectly dry and seasoned, and fit for use. Large timbers will require a proportionate time, according to their thickness.

The solution may be used ad infinitum, as its strength is not diminished; but it will be advisable to ascertain occasionally by the hydrometer that it contains the required proportions of corrosive sublimate and water.

Professor Faraday and the late Dr. Birkbeck have, with many other scientific men, testified in the strongest manner to the efficacy of this solution. The former says, with respect to the penetration of the solution by steeping, without pressure, that it may be tested by the application of a drop of hydrosulphuret of ammonia, which will turn black on meeting with the mercury.

In the cube of elm, the corrosive sublimate may be traced by the above test to the depth of from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch; by the test of voltaic action, from $\frac{3}{4}$ to 1 inch.

In the cube of oak, with the same test, it was found at $\frac{1}{4}$ of an inch, *but irregular*, and apparently fol*lowed the fissures* of the wood; by *voltaic action*, not quite so far as *in the elm*.

In the cube of fir, the penetration was the least by the common test, $\frac{1}{8}$ to $\frac{1}{5}$ of an inch; by voltaic action, $\frac{1}{2}$ of an inch, the turpentine in the wood probably being the obstruction to penetration.

From this testimony it is evident that when pressure is not used, the timber should be worked up into the form required before immersion.

The patentees or company, who have also the means of saturating with hydraulic pressure at their establishment, similar to that at Portsmouth Dockyard, under Sir William Burnett's process, grant licenses at the rate of 5*s*. per cubic foot internal dimensions of the tank, and sell corrosive sublimate at 4*s*. per lb.

$1\frac{1}{2}$ lb. is sufficient to saturate a load of timber of 50 cubic feet, at the rate of 1 lb. of sublimate to 15 gallons of water.

The process has been for several years extensively used for sleepers on railroads.

Several of the sleepers on the South Western Railway, which had been subjected to this process, were taken up, owing to their being decayed, particularly in the chalk districts. It was, however, stated by the engineer that they had been steeped at the company's works in a hasty manner, and that he did not consider it conclusive against the process; that he had never seen any wood decayed that had been steeped by the patentees. It is also said that neither Kyan's, Burnett's, nor Payne's process, can resist the combined effects of moisture and great heat, say 80° Fahr.

BURNETTIZING.

Burnettizing is the process by means of which timber, felt, canvas, cordage, cottons, and woollens, may be preserved from dry-rot, mildew, moth, and premature decay. It takes its name from its inventor, Sir William Burnett, M.D., K.C.B., F.R.S., of the Navy, who took out a patent for it in 1837.

onsists in immersing the
substances above enume-
a a solution of chloride of
d water in a wooden tank,
proportion of 1 lb. of chlo-
zinc to 4 gallons of water
d, and 1 lb. of the chloride
allons of water for the re-
r of the articles, with the
on of felt, which requires
the chloride to 2 gallons of

e-inch deals require to re-
n the tank or cistern six
nd all other woods in the
roportion, or two days per
They are then taken out and
der a shed, on their ends, to
d require for this purpose
urteen days to three months,
ng to the thickness of the
when they are fit for use.
timber should be reduced to
ntling required for use before
bjected to this process.
ras, yarn for cordage, cottons,
oollens, require to be sus-
l in the solution for forty-
ours.
process, however, with re-
o timber, is much more ex-
usly and effectively done by
lic pressure in Her Majesty's
rd at Portsmouth, where
quantities of timber, &c., are
ed for the use of the Royal
at the various dockyards in
d, particularly for ships'
ines.
re is a large wrought-iron
52 feet in length and 6 feet
meter, with a door 2 feet 6
× 2 feet at each end for
g.
ber of all sizes and descrip-
put into this cylinder, which
ns about twenty loads. As
s it is filled, and the doors
ecured both against external
ternal pressure, the air is ex-
d in the cylinder, and also in
mber, *by means of* an air-
worked by a small rotatory
of 10-horse power, on the
Earl of Dundonald's principle, until the barometer stands at 27°: the valve leading to the air-pump is then shut, and the cock of a pipe leading from the tank, filled with the solution, to the cylinder, is turned: the solution rushes into the cylinder to fill up the partial vacuum, and about half-fills it, when the cock is turned, and the air-pump again set to work until the barometer stands at 27½°, when the same process is repeated, and the cylinder nearly filled with the solution.

A pressure of 150 lbs. per square inch is then obtained by means of a Bramah forcing-pump, connected with an iron copper or reservoir, filled with the solution, and communicating with the cylinder by means of a pipe. This is worked by hand until a valve placed on the top of the cylinder, and loaded to the required gauge, begins to lift.

The timber is then left in the cylinder, subject to this pressure, for eight hours, which is considered sufficient for the largest logs, even in a rough state. The solution being then drawn off into the tank, and the timber taken out of the cylinder, it is re-loaded, and the process repeated: the same solution is used for two months, when fresh is prepared.

The same process for drying the timber thus saturated is adopted, as before stated. Canvas, felt, and yarn, &c. are not subjected to pressure.

The felt is used as a lining to the magazines of men-of-war, between two thicknesses of wood; also to cover over the steam boilers of steam ships: it is said to be rendered much less liable to combustion by the process.

It is stated that in tropical climates, more especially in Africa, the saturated canvas has stood the climate, when the unprepared, under similar circumstances, has rapidly decayed.

Both Burnettizing and Kyanizing offer great advantages to the engineer:

1st. Wood of every kind is rendered more durable, and is rapidly seasoned.

2ndly. It brings into general use larch, poplar, and a variety of other indigenous woods, as well as American pine, &c., which, without the process, from being liable to rapid decay, and being much inferior to Baltic timber, are seldom used in public buildings.

To the military engineer, these inventions offer still greater advantages. He is frequently called on, in distant colonies, to construct block-houses, stockades, bridges, and barracks, where the only material to be had in abundance is the tree standing in the forest: to him a few pounds of either ingredient would be invaluable, by enabling him to season and render durable the timber a few days after it was cut down, and thus provide him with the ready means of rendering a distant post tenable in a short time by a small body of men, with the additional satisfaction of knowing that the work thus hastily erected would be found to be of a permanent nature.

LAB

LABURNUM, a small dark-greenish broom-wood, is sometimes used in ornamental cabinet-work

Labyrinth, a series of hedges, mounds, or walls, with numerous winding passages; intricate and winding walks in a garden

Lacing, a piece of compass or knee-timber, fayed to the back of the figure and the knee of the head of a ship, and bolted to each

Lacker, a varnish applied upon tin, brass, and other metals, to preserve them from tarnishing, and to improve their colour

Lac lake is prepared from lac, an Indian drug. It resembles cochineal and kermes, being the production of a species of insect. Its colour is rich, transparent, and deep, —less brilliant, and more durable than those of cochineal and kermes, but inferior in both these respects to the colour of madder.

Laconicum, among the ancients, the semicircular end of a bath; a circular stove, for the purpose of heating the sudatories, or sweating-rooms of a bath: the use of the dry bath is said to have been prevalent among the Lacedæmonians

Lacquer. See *Lacker*.

Lacunaria, the ceiling of the ambulatory around the cella of a temple or of the portico. The beams, which extended from the walls to the entablature, were intersected by others ranged longitudinally: the square spaces made by these intersecting beams were contracted towards the top, and were sometimes closed with single stones, which might occasionally be removed.

LAC

Lacunars, in architecture, are panels or coffers in the ceilings of apartments, and sometimes in the soffits of the corona of the Ionic, Corinthian, and Composite orders

Lady-chapel, a chapel dedicated to the blessed Virgin

Lake (colour), a name derived from the lac or lacca of India, is the cognomen of a variety of transparent red and other pigments of great beauty, prepared for the most part by precipitating coloured tinctures of dyeing drugs upon alumine and other earths, &c. The lakes are hence a numerous class of pigments, both with respect to the variety of their appellations and the substances from which they are prepared. The colouring matter of common lake is Brazil wood, which affords a very fugitive colour. Superior red lakes are prepared from cochineal, lac,

and kermes; but the best of all are those prepared from the root of the rubia tinctoria, or madder-plant. See *Lac lake*.

Lama, in mining, slime or schelm

Laminæ, the extremely thin plates or layers of metal which compose the solid metal

Laminable, a term applied to metal which may be extended by passing it between steel or hardened (chilled) cast-iron rollers

Laminated, disposed in layers or plates. When metal can be readily extended in all directions, under the hammer, it is said to be malleable, and when in fillets under the rolling-press, it is said to be laminable.

Lamp-black is a smoke-black, being a soot of resinous woods obtained in the manufacturing of tar and turpentine. It is a pure carbonaceous substance of a fine texture, intensely black and perfectly durable, which works well, but dries badly in oil

Lance wood, imported in long poles from 3 to 6 inches in diameter, from Cuba and Jamaica, is of a paler yellow than box wood: it is selected for elastic works, as gig shafts, archery bows and springs, surveyors' rods, billiard cues, &c.

Landscape. In landscape we find Nature employing broken colours in enharmonic consonance and variety, and equally true to picturesque relations: she employs also broken forms and figures in conjoint harmony with colours, occasionally throwing into the composition a regular form or a primary.

Landscape Gardening. The outline of a wood may sometimes be great, and always beautiful, but the first requisite is irregularity. That a mixture of trees and underwood should form a long straight line, can never be natural; and a succession of easy sweeps and gentle rounds, each a portion of a greater or less circle, composing altogether a line literally serpentine, is, if possible, worse; it is but a number of regularities put together in a disorderly manner, and equally distant from the beautiful, both of art and of nature.

The true beauty of an outline consists more in breaks than in sweeps; rather in angles than rounds; in variety, not in succession. The outline of a wood is a continued line, and small variations do not save it from the insipidity of sameness: one deep recess, one bold prominence, has more effect than twenty little irregularities; and that one divides the line into parts, but no breach is thereby made in its unity: a continuation of wood always remains, the form of it only is altered, and the extent increased: the eye, which hurries to the extremity of whatever is uniform, delights to trace a varied line through all its intricacies, to pause from stage to stage, and so lengthen the progress.

The parts must not, however, on that account, be multiplied till they are too minute to be interesting, and so numerous as to create confusion: a few large parts should be more strongly distinguished in their forms, their directions, and their situations: each of these may afterwards be decorated with subordinate varieties, and the mere growth of the plants will occasion some irregularity: on many occasions more will not be required. Every variety in the outline of a wood must be a prominence or a recess; breadth in either is not so important as length to the one and depth to the other: if the former ends in an angle, or the latter diminishes to a point, they have more force than a shallow dust or a dwarf excrescence, how wide soever: they are greater deviations from the continued line which they are intended to break, and their effect is to enlarge the wood itself.

Every variety of outline hitherto mentioned may be traced by the underwood alone; but frequently

the same effects may be produced with more ease, and much more beauty, by a few trees standing out from the thicket, and belonging or seeming to belong to the wood, so as to make a part of its figure.

The materials of natural landscape are ground, wood, and water, to which man adds buildings, and adapts them to the scene: it is therefore from the artificial considerations of utility, convenience, and propriety, that a place derives its real value in the eyes of a man of taste: he will discover graces and defects in every situation; he will be as much delighted with a bed of flowers as with a forest thicket, and he will be as much disgusted by the fanciful affectation of rude nature in tame scenery as by the trimness of spruce art in that which is wild.

Landscape Painting. The best painters in landscape have studied in Italy or France, where the verdure of England is unknown: hence arises the habit acquired by the connoisseur, of admiring the brown tints and arid foregrounds in the pictures of Claude and Poussin; and from this cause he prefers the bistre sketches to the green paintings of Gainsborough. One of our best landscape painters studied in Ireland, where the soil is not so yellow as in England; and his pictures, however beautiful in design and composition, are always cold and chalky. Autumn is the favourite season of study for landscape painters, when all nature verges towards decay, when the foliage changes its vivid green to brown and orange, and the lawns put on their russet hue: but the tints and verdant colouring of spring and summer will have superior charms to those who delight in the perfection of nature, *without* perhaps ever considering *whether they* are adapted to the *painter's* landscape.

Land Steward. A person solely occupied in the management and cultivation of an estate should see to the production, advancement, and value of the land; should be well acquainted with the pursuits and interests of country life; should understand the qualities of the soil and the proper manuring of the same, as well as the different combinations of sand, gravel, loam, clay, chalk; he should be able to show what stock the pasture will maintain, what quantity of grain the arable land will produce, and what quantity of hay may be expected from the meadows: with other requisite knowledge pertaining to farming, he will be able to form a fair estimate of the produce of the farm, to keep accounts, and ultimately acquire a taste for the erection of farm buildings and labourers' rural cottages, and also the arrangement of landscape, flower, and vegetable gardens.

Laniard, in navigation, a stout piece of line or cord used to fasten and secure the shrouds, stays, or buoys

Lantern, in architecture, a small structure on the top of a dome or in similar situations for the admission of light, and the promotion of ventilation. It is generally made ornamental, and was much used in Gothic and Tudor architecture.

Lapidarius, a lapidary, a stone-cutter

Lapis lazuli, a mineral which furnishes the valuable pigment called ultramarine

Lapis lydius, a variety of touch-stone; the schistose jasper of Brongniart, containing silica, iron, alumina, and charcoal

Laque Minérale is a French pigment, a species of chromic orange. This name is also given to orange oxide of iron.

Larboard, in navigation, the left-hand side of a ship, standing with face to the head: now the word 'Port' is used

Lardrose, a screen at the back of a seat behind an altar

Later, a brick or tile. Besides the

Greeks and Romans, other ancient nations employed brick for building to a great extent, especially the Babylonians and Egyptians.

Lathe, a machine for turning metals or wood by causing the material to revolve upon central points, and be cut by a tool fixed in a slide-rest, or held by hand.

The lathe is very ancient, and seems to have been known to the Greeks and Romans, but, till within the last half century, was a very rough and almost powerless machine compared with the elegant, very powerful, and well constructed machine now in use. It is used for turning either metal or timber, and varies in size and construction, according to the nature of the work required.

The construction of the present lathe is as follows: a long frame, called the lathe-bed, having a perfectly planed surface, and a slot or mortise from end to end, is fixed at each end upon two short standards, and upon one end of it a frame, called the head-stock or mandril-frame, is bolted: this frame carries the short shaft or mandril, upon which are the driving pulleys. The end of the mandril stands through the inner side of the frame, and is screwed so that a socket or centre chuck may be fixed on it: this chuck acts as a centre for the work to rest upon, and has a projecting arm or driver to carry it round with it. Another frame, called the back centre frame, capable of being fixed upon the lathe-bed at any distance from the front centre, has a cylinder, with a pointed end or centre, at precisely the same height as the other, with two set-screws, one to adjust the centre piece, the other to fix it. The work is placed between these two centres, and caused to revolve by a band passing over a pulley on the mandril, if the lathe is large, and by a treddle and band-wheel, if the lathe is small.

In small lathes, the rest, upon which the tool is held, is fixed in a socket cast on a small slide by a set-screw: the slide is for adjusting its position, and is capable of being fixed at any part of the lathe-bed between the centres.

In large lathes the slide-rest is always used. See *Slide-rest*.

Lathe-bed, that part of a lathe on which the 'poppet-head' slides forward or backward to its required position

Latitude, breadth, width, extent; in geography, the distance, north or south, from the equator, a great circle, equally distant from the poles, dividing the globe into equal parts, north and south

Latten, a mixed metal resembling brass. The monumental brasses in churches are called latten.

Lattern-sail, in navigation, a long triangular sail used in xebecs, &c.

Launders, in mining, tubes and gutters for the conveyance of water in mines, &c.

Lavatory, a cistern or trough to wash in, used formerly in monasteries

Laver, brazen. Moses was directed to make, among other articles of furniture, for the services of the tabernacle, a laver of brass, borne by four cherubim, standing upon bases or pedestals, mounted on brazen wheels, and having handles belong-to them, by means of which they might be drawn and conveyed from one place to another, as they should be wanted. These lavers were double, composed of a basin which received the water that fell from another square vessel above it, from which the water was drawn by cocks. The whole work was of brass: the square vessel was adorned with the heads of a lion, an ox, and a cherub. Each of the lavers contained forty baths, or four bushels, forty-one pints, and forty cubic inches of Paris measure.

Lay figure, a figure made of wood or cork, in imitation of the human body. It can be placed in any position or attitude, and moves at

every joint, on the principle of the ball and socket. It serves, when clothed, as a model for drapery and for fore-shortening. The dress of the person is generally placed on the lay-figure after the head is taken, by which the painter finishes his entire portrait at leisure, without requiring the person to sit.

Lazaretto, an hospital ship for the reception of the sick

Lead is a very heavy metal, sufficiently well known. The mode of purifying it from the dross which is mixed with it, by subjecting it to a fierce flame, and melting off its scoria, furnishes several allusions in Scripture to God's purifying or punishing his people. It was one of the substances used for writing upon by the ancients

Leader, a branch, rib, or string of ore, leading along to the lode

Lead spar, sulphate of lead

Leading springs, the springs fixed upon the leading axle-box of a locomotive engine, bearing the weight above

Leading wheels, the wheels of a locomotive engine, which are placed before the driving wheels

Leat, a water-course, or level for conveyance of water

Leaves, a term applied to window-shutters, the folding-doors of closets, &c.

Leaving (in Cornish), or *casualties*, in tin, is the same as *hanaways* of copper or lead ore

Lectern or *Lettern*, the desk or stand on which the larger books used in the services of the Roman Catholic church are placed. In modern Protestant churches they are now often used, and are very ornamental in appearance, and far more appropriate than the cumbersome reading-desk. Lecterns are made sometimes of stone or marble, but *usually of* wood and brass, and *generally* are extremely well executed.

Lectus, a bed or couch

Ledger, a large flat stone laid over a tomb: horizontal timbers used in forming scaffolding are also called ledgers

Ledgment, a string-course, or horizontal suite of mouldings, such as the base-mouldings of a building

Lee, in navigation, the side opposite to the wind; as the lee-shore is that on which the wind blows

Lembus, according to Plautus, a skiff or small boat, used for carrying a person from a ship to the shore

Lemon yellow, a beautiful light and vivid colour. In body and opacity it is nearly equal to Naples yellow and masticot, but much more pure and lucid in colour and tint, and at the same time not liable to change by damp, sulphurous or impure air, or by the action of light, or by the steel palette-knife, or by mixture of white lead or other pigments, either in water or oil.

Levecel, anciently a pent-house, or a projecting roof over a window, door, &c.

Level, an instrument for determining the heights of one place with respect to another

Levelling, the art by which the relative heights of any number of points are determined.

The height of a point is the vertical distance to which it is elevated or depressed, as compared with the true general surface of the earth.

The earth is in form a spheroid. On land we can nowhere trace its true geometric surface; but the sea, when at rest, presents every where a very near approximation to it, and hence the level of the sea has been assumed as the standard to which all heights are to be referred.

The absolute height, then, of any point is its vertical distance from the level of the sea: the relative height of two or more points, commonly called their difference of level, is the difference of those vertical distances.

A true level is any surface or

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ily present a curve every
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or below that point; and
tical distance at which it so
s the measure of its relative

eory, levelling is extremely
It consists in tracing
space a series of level sur-
and finding their intersec-
with vertical lines passing
the points whose relative
we wish to ascertain.
d, a triangular frame of wood
long straight base, and a
et suspended by a thread
ne vertex of the triangle.
the ground to which it is
is level, the thread will co-
with a line perpendicular to
e.
ol similar in principle to the
nentioned is used by fitters,
made of a plate of sheet-
wo sides of which form a
ngle, and the thread which
ls the plummet is parallel to
tical side when the base is

irit, a glass tube, closed at
ds, and nearly filled with
or spirits, fixed in a piece of
r metal, with a flat base, to
he tube is perfectly parallel.
placed upon a level surface,
bubble will be at the centre
tube.
e first mechanical power,
an *inflexible straight* bar,
ed in a single point on a
or prop, called its centre

of motion: it is used to elevate a great weight

Lever-valve, a safety-valve kept in its seat by the pressure of a lever with an adjustable weight. In locomotive engines a spring is used at the end of the lever, instead of the weight; and the pressure is regulated by a screw, and indicates on a brass plate.

Levigation, the process of reducing hard bodies into subtile powder by grinding upon marble with a muller

Lewis, an instrument used by masons for hoisting, consisting of thin wedges of iron, forming a dovetail, which is indented into a large stone for the purpose of moving it

Ley, a standard of metal; contents in pure metal

Libella, a small balance; a level used by carpenters and masons, to test flat surfaces

Libra, a pound weight; a balance, or a pair of scales: one of the twelve signs of the zodiac

Library, a room or rooms appropriated for the arrangement and keeping of books, fitted up with shelves to hold them, or furniture called book-cases, to which shelves are affixed for the same purpose

Lifts, in navigation, the ropes at the yard-arms, used to make the yards hang higher or lower, as required

Lifting-gear, the apparatus for lifting the safety-valves from within a boiler: it consists of levers connected to the valve and to a screw worked by a handle outside the boiler

Light. The meteorological phenomena induced by the action of light are, chiefly, atmospheric refraction, *i.e.* the temperature of the different strata of the atmosphere; the tints which at certain times spread over the disc of the sun, the moon, and the stars; the various aspects of the waters of the ocean, of seas, and of lakes; the Fata Morgana, the mirage, and all those varied optical appearances which both celestial and terrestrial objects present when seen through atmosphe

ric strata of different degrees of elasticity.

Light red is an ochre of a russet-orange hue; principally valued for its tints. The common light red is brown ochre burnt; but the principal yellow ochres afford this colour best; and the brighter and better the yellow from which this pigment is prepared, the brighter will this red be, and the better flesh-tints will it afford with white.

Lignum vitæ, or *Guaiacum*, is a very hard and heavy wood, shipped from Cuba and other adjacent islands. When first cut, it is soft and easily worked; but it speedily becomes much harder on exposure to the air. It is cross-grained, covered with a smooth yellow sap, like box, almost as hard as the wood, which is of a dull brownish green, and contains a large quantity of the gum guaiacum, which is extracted for the purposes of medicine. The wood is used in machinery, and for rollers, presses, mills, pestles and mortars, sheaves for ships' blocks, skittle-balls, &c.

Limber boards, short pieces of plank fitted from the limber strake to the keelson of a ship, butting at the sides of all the bulk-heads, that they may be easily taken up

Limber strake, the strake of wood waleing nearest the keelson, from the upper side of which the depth in the hold of a vessel is measured

Lime or *Quicklime*. When required perfectly pure, lime is obtained by heating to whiteness, in an open platinum crucible, precipitated carbonate: most marbles yield it moderately pure; but as prepared for ordinary purposes, by the calcination of common limestone in a furnace with coal, it is far otherwise

Limestone becomes lime on being deprived of its carbonic acid and of the water it contains, whether hygrometrically or in combination. The agent employed to effect this is heat.

With the same heat, the calcination is effected with more ease and rapidity, in proportion as the stone is of a less compact texture than the smallness in bulk of the fragments into which it is reduced, or to its being impregnated with a certain degree of humidity.

The contact of the air is not indispensable, but it exercises a useful influence, especially in regard to argillaceous limestone. Moreover, no limestone can be converted into lime in a vessel so close as to render the escape of the carbonic acid impossible.

Limestone which is pure, or nearly so, supports a white heat without inconvenience. Under the intense heat of the hydro-oxygen blow-pipe this substance affords the brilliant light, the beautiful application of which to the microscope is now so well known. The compound limestone, on the other hand, alloyed in the proportions necessary to form hydraulic or eminently hydraulic lime, fuses easily. Its calcination demands certain precautions: the heat ought never to be pushed beyond the common red heat, the intensity being made up for by its duration.

The compound limestone, when too much burnt, is heavy, compact, dark-coloured, covered with a kind of enamel, especially about the angular parts; it slakes with great difficulty, and gives a lime carbonized and without energy: sometimes it will not slake at all, but becomes reduced, after some days' exposure to the air, to a harsh powder altogether inert.

The pure and compound limestones, when insufficiently burnt, either refuse to slake, or slake only partially, leaving a solid kernel, a kind of sub-carbonate with excess of base.

The calcining of calcareous minerals constitutes the art of the lime-burner. According to situation, either fire-wood, fagots, brushwood, turf, or coal is used.

Lime-kilns of various kinds have have been suggested or tried. The forms of interior most generally adopted are, 1st, the upright rectangular prism; 2nd, the cylinder; 3rd, the cylinder surmounted by an erect cone slightly truncated; 4th, a truncated inverted cone; 5th, an ellipsoid of revolution variously curvated, or egg-shaped kiln.

The rectangular kilns are in use in Nivernais, and in the south of France, in which are burnt, at the same time, limestone and bricks. The limestone occupies very nearly the lower half of the capacity. The upper is filled with bricks, or tiles, laid and packed edgewise.

The cylindric kilns are principally employed upon works which consume a large quantity of lime in a short time. They are termed 'field-kilns;' their construction is expeditious and economical, but precarious. Above a pointed oven-shaped vault, is raised, in the form of a tower, a high stack of limestone, which is enclosed by a curtain of rammed earth, and supported outwardly by a coarse wattling, in which care is taken to leave an opening to introduce the fire beneath the vault.

The kilns of the third kind are constructed in a solid and durable manner, like the four-sided kilns: no bricks are burnt in these; the largest stones occupy the lower part of the cylinder; the smaller pieces and fragments are thrown into the cone which surmounts it.

The kilns of the fourth and fifth kind are specially intended for the burning with coal.

The interior wall of the kiln is generally built with bricks, or other material unalterable by heat, cemented throughout a thickness of from 12 to 15 inches with a mixture of sand and refractory clay, beaten together.

In the flare-kilns fed by logs or brush-wood, the charge always rests upon one or two vaults built up dry with the materials of the charge itself. Underneath these vaults a small fire is lighted, which is gradually increased as they retire, in proportion as the draught establishes itself, and gains force. On reaching the exterior, the aperture at the eye of the kiln is suitably adjusted, and then kept constantly filled with the combustible. The air which rushes in carries the flame to a distance over every point of the vaults: it insinuates itself by the joints, and is not long in extending the incandescence by degrees to the highest parts.

There are some kinds of stone which the fire, however well regulated, seizes suddenly, and causes to fly with detonation: they cannot, without the risk of spoiling the charge, be used for the construction of the vaults and piers in loading the kiln. In such a case, materials which are free from this inconvenience are employed.

Practice can alone indicate the time proper for the calcination. It varies with a multitude of circumstances, such as the more or less green, more or less dry quality of the wood; the direction of the wind, if it favour the draught, or otherwise, &c. The master-burners usually judge by the general settling of the charge, which varies from $\frac{1}{5}$ to $\frac{1}{8}$. In a kiln of the capacity of from 211·8 to 264·75 cubic feet, the fire lasts from 100 to 150 hours.

In the coal-kilns by slow heat, the stone and coal are mixed. Of all the methods of burning lime, this is certainly the most precarious and difficult; more especially when applied to the argillaceous limestone. A mere change in the duration or intensity of the wind, any dilapidation of the interior wall of the kiln, a too great inequality in the size of the fragments, are so many causes which may retard or accelerate the draught, and occasion irregular movements in the descent

of the materials, which become locked together, form a vault, and precipitate at one time the coal, and another the stone, upon the same point: hence an excess or deficiency in the calcination.

Sometimes a kiln works perfectly well for many weeks, and then all at once gets out of order without any visible cause. A mere change in the quality of the coal is sufficient to lead the most experienced lime-burner into error. In a word, the calcination by means of coal, and the slow heat, is an affair of cautious investigation and practice.

The capacity of a furnace contributes, no less than does its form, to an equable and proper calcination. There are limits beyond which they cannot be enlarged without serious evils.

The bulk of coal burnt to produce a cubic foot of lime necessarily varies with the hardness of the limestone used, but within narrow limits.

The calcination of limestones presents other important problems, which can only be solved by experiment.

Limes, hydraulic (artificial). Already the artificial limes have been applied to a number of important works. In the canals of Saint Martin and Saint Maur they have almost exclusively been used. Nearly a thousand cubic metres have been employed within five years at the harbour of Toulon. These limes have served for the fabrication of the mortar for the foundations of several bridges, and their consumption is increasing daily in Paris and its environs.

The artificial hydraulic limes are prepared by two methods: the most perfect, but also the most expensive, consists in mixing with rich *lime, slaked* in any way, a certain *proportion of* clay, and calcining *the mixture: this* is termed '*artificial lime twice kilned.*'

By the second process, any soft calcareous substance is stituted for the lime (such, fo ample, as chalk, or the tufas), v it is easy to bruise and reduce paste with water. From tl great saving is derived, but a same time an artificial lime, pe of not quite so excellent a qu as by the first process, in c quence of the rather less pe amalgamation of the mixture. fact, it is impossible, by mere chanical agency, to reduce c reous substances to the same d of fineness as slaked lime. N theless, this second process i more generally followed, and results to which it leads be more and more satisfactory.

By a proper regulation o proportions, a degree of e may be given to the factitious which will render equal it i superior to the natural hyd limes.

It is usual to take twenty pa dry clay to eighty parts of rich lime, or to one hundre forty of carbonate of lime. But lime or its carbonate should al be at all mixed in the natural then fifteen parts of clay w sufficient. Moreover, it is p to determine the proportion every locality. In fact, all do not resemble one another to an extent as to admit of being considered as identical finest and softest are the best

There is at Meudon, near a manufactory of artificial lim on foot by Messrs. Brian an Leger. The materials made are, the chalk of the countr the clay of Vaugirard, whi previously broken up into lun a moderate size. A millsto up edgewise, and a strong with spokes and felloes, firm tached to a set of harrows and are set in movement by a horse gin, in a circular b about six feet and a half

In the middle of the basin is a pillar of masonry, on which turns the vertical arbor to which the whole system is fixed: into this basin, to which water is conveyed by means of a cock, four measures of chalk are successively thrown, and one measure of clay. After an hour and a half's working, about fifty-three cubic feet (English) of a thin pulp is obtained, which is drawn off by means of a conduit, pierced horizontally on a level with the bottom of the basin.

The fluid descends by its own weight; first into one excavation, then into a second, then a third, and so on to a fourth or fifth. These excavations communicate with one another at top. When the first is full, the fresh liquid, as it arrives, as well as the supernatant fluids, flow over into the second excavation; from the second into the third, and so on to the last, the clear water from which drains off into a cesspool. Other excavations, cut in steps like the preceding, serve to receive the fresh products of the work, whilst the material in the first series acquires the consistency necessary for moulding. The smaller the depth of the pans in relation to their superficies, the sooner is the above-mentioned consistency obtained.

The mass is now subdivided into solids of a regular form by means of a mould. This operation is executed with rapidity. A moulder, working by the piece, makes on an average five thousand prisms a day, which will measure 211·8 cubic feet. These prisms are arranged on drying shelves, where in a short time they acquire the degree of desiccation and hardness proper for calcination. At Paris a mixture of coke and coal is employed, and the common mode of burning by slow heat rendered necessary by that kind of combustible.

The artificial hydraulic limes are intended to supply the place of the natural ones in those countries where the argillaceous limestone is entirely wanting, and which are commonly sold in Paris.

Lime-tree (the) is common in Europe, attains considerable size, is very light-coloured, fine and close in the grain, and is used in the construction of piano-fortes, harps, &c.: it is particularly suitable for carving, from its even texture and freedom from knots. The works of Gibbons at Windsor Castle, and St. Paul's, London, are of the lime-tree.

Limning, a term formerly applied to portrait-painting, is drawing or painting the body and limbs of the human figure

Linch-pin, the small pin in carts, &c., that is put at the ends of the axle-tree to confine the wheels on them steadily

Linear perspective is that which describes or represents the position, magnitude, form, &c. of the several lines or contours of objects, and expresses their diminution, in proportion to their distance from the eye

Link-motion, a new apparatus for reversing steam engines: it is used in locomotive engines instead of the reversing forks, and consists of a link with a slot from end to end, into which a guide-block fits, and is connected to the slide-valve rod: the rods of the two eccentrics are connected one to each end of the link, which is raised or lowered, or held in a central position by apparatus attached to the centre of it, moved by the reversing lever. When the link is in a central position with regard to the slide-valve rod, the guide-block remains stationary, as it is then at the centre upon which the link vibrates. When the link is up, the guide-block is at the lower end, and the slide receives motion from the backward eccentric. When the link is down, it receives motion from the forward eccentric.

Links, in locomotive engines, are flat or round pieces of iron with round holes at each end: they are used to connect together, by bolts, different parts of the mechanism of the engine

Lintel, a piece of timber or stone placed horizontally over a doorway or window, to support the superincumbent weight

Lintel. "And ye shall take a bunch of hyssop, and dip it in the blood that is in the basin, and strike the lintel and the two side-posts with the blood that is in the basin; and none of you shall go out at the door of his house until the morning."—*Exodus* xii. 22.

Liquid rubiate, or *Liquid madder lake*, is a concentrated tincture of madder, of the most beautiful and perfect rose colour and transparency. It is used as a water colour only in its simple state, diluted with pure water, with or without gum; it dries in oil, by acting as a dryer to it. Mixed or ground with all other madder colours, with or without gum, it forms combinations which work freely in simple water, and produce the most beautiful and permanent effects.

Lithography, the art of drawing on and engraving on stone, and taking impressions from the same at press, similarly to copper-plate printing, but differing in manipulation

Little winds, in mining, an underground shaft, sunk from the horizontal drift, by which the top of the winds communicates with the side or bottom of the great working-shaft

Load water-line, the mark on a ship which the water makes when she is loaded

Loam, a natural mixture of sand and clay: in the neighbourhood of London, loam consists of fine reddish-gray sand 87 parts, allumina 13 parts = 100

Local colours are such as faithfully imitate those of a particular object, *or such as* are natural and proper for each particular object in a picture; and colour is distinguished by the term trial, because the place it fills requires that particular colour, in order to give a greater character of truth to the several colours around it

Lock, a mechanical contrivance to fasten a door, gate, or any place or thing for security. A vast deal of ingenuity has been exercised to prevent false openings: keys of various kinds are made to fit the wards (interior contrivances), and prevent what is called picking, the key being made only to suit that belonging to the possessor.

Lock, in inland navigation, a portion of a canal confined between a sluice-gate and a flood-gate, to facilitate the passage of boats in ascending or descending planes

Lockrand, a course of bond stones, or a bonding course, in masonry

Locks for canal and river navigation. The earliest approximation to what is now known by the name of lock consisted of a simple dam formed across the bed of a river, so as to raise the water to such a height as to allow vessels to float along it. Where the river had a considerable fall with a strong current, it was necessary to have these dams at short distances from each other, otherwise the requisite depth of water could not be obtained. As the whole space between two of these dams was in fact the lock, it was necessary, in passing from one level to another, to run down the water for the whole of that distance, thereby causing considerable delay, and a waste of water that would now be considered a serious evil. In China these dams are common, and they have also been used on the Continent.

Lock with a double set of gates, but no chamber walls, are now of ordinary construction. The evils attendant on the dams formerly constructed were in a great measure removed by the introduction

of double sets of gates or sluices; the upper set being constructed so near to the lower as only to leave room enough for the vessel or vessels to float between them. Framed gates were also used instead of separate beams and planks, because the space to be emptied or filled was so small that a very short time was required to pass the water, and there was no stream of sufficient strength to prevent their being easily opened. Where these locks are intended for rivers, it is usual to make a side cut or artificial canal for the purposes of the navigation, and to leave the river course for the passage of the surplus water. A quick bend of the river is generally chosen for one of these cuts; and to keep the water in the upper part of the river to a sufficient height for navigation, a dam or weir is made across the old river course at or below the point where the artificial cut quits it. The lock is then built at the most convenient part of the cut, and its fall made equal to the difference in the levels of the water at the top and at the bottom of the dam or weir. When a vessel is going up the river, she floats along the cut, and passes between the lower gates into the lock; the lower gates are then closed, and the valves or paddles of the upper gates being opened, the water flows into the lock, and rises to the level of the upper part of the river; the upper gates are then opened, and the vessel floats out of the lock. The reverse of this operation conducts a vessel down the river.

The abutments for the gates have been made of timber, brick-work, and masonry; but when the double set of gates was first introduced, it was usual to leave the space between the upper and lower gates unprotected by either timber or any kind of building. Of course the agitation of the water in the lock was constantly washing away the earthen banks, thereby causing a risk of their being broken down by such continued weakening; and by enlarging the space between the two sets of gates, it occasioned a loss of time in emptying and filling, as well as a waste of water.

Lock (common modern canal).—The difference of altitude between the upper and lower levels, where the locks are constructed, varies according to local circumstances. Where the ground is longitudinally steep and water plentiful, the locks are generally made of greater lift or fall than where the ground is comparatively flat and water scarce. It is evident, that where the superficial area of locks is the same, one having a rise of 12 feet would require twice the quantity of water to fill it that would be requisite for one of 6 feet. Having many locks, however, of small lifts instead of a few of greater, increases the expense, as well as the time for passing them.

For narrow canals these locks are generally made about 80 feet long, and 7½ to 8 feet wide in the chamber. On the Caledonian canal they are 180 feet long, 40 feet wide, and 30 feet deep. Locks are also constructed of every intermediate size.

Lock-gates have till lately been made of timber; but in consequence of the difficulty of procuring it of sufficient size for those on the Caledonian canal, cast iron was partially adopted for the heads, heels, and ribs. Iron gates, cast in one piece, have been used on the Ellesmere canal, as well as others with cast-iron framing and timber planking.

Locks with side ponds.—When water is scarce, it is common to construct side ponds, by which a considerable portion (in general one-half) is saved. The usual number of these ponds is two; for it has been determined by experience, that when a greater number has been made

use of, the loss occasioned by leakage and evaporation has sometimes been more than equal to the additional quantity of water thus retained.

Locks for the transit of vessels of different sizes.—Where vessels of different sizes have to pass the same locks, three pairs of gates are sometimes placed instead of two, —the distance between the upper and lower pairs being sufficient to admit the largest vessels, and that between the upper and middle pairs being adapted to the smaller class. By this contrivance, when a small vessel is to be passed through, the lowest pair of gates is not used; and when a large vessel goes through, the middle pair of gates is not worked. Thus it is evident that the quantity of water contained between the middle and lower pair of gates is saved when a small vessel passes, compared with what would be required were the middle set of gates omitted.

Locks (parallel double-transit).—Where the transit is great, much time and water may be saved by a double-transit lock, which is two locks placed close to and parallel with each other, with a communication between them, which can be opened or cut off at pleasure by valves or paddles.

As one of these locks is kept full and the other empty, a vessel in descending floats into the full one: the upper gates are then closed, and the water is run, by means of the connecting culvert, into the empty lock (the gates of which were previously closed), till the water in the two locks is on the same level, which will be when each is half-full: the connecting paddles are then closed, and the remaining half of the water in the descending lock is run into the lower canal. The next descending vessel has to be floated into the *lock which* remains half-filled, and *which consequently* requires only half a lock of water to be run from the upper pond to raise it to the proper level, and then that half is transferred to the lock previously used, to serve the next descending vessel; but supposing a vessel to be ascending after the first descent, it will enter the empty lock, and receive a quarter-lock of water from that which remained half-filled: of course, three-quarters of a lock of water is now required from the upper canal to complete the filling. If a descending vessel next follows, it enters the full lock, and its water is run into the lock which was previously left a quarter-full; and when both have arrived at the same level, it is evident they will be each five-eighths full, and the succeeding descending vessel will require only three-eighths of a lock of water from the upper pond or canal. From these observations, it will be seen that the double-transit lock saves nearly one-half of the water which a common single lock would require.

Sometimes the two parallel locks are made of different sizes, to suit the various descriptions of vessels that may have to pass.

Locks connected longitudinally, commonly called a Chain of Locks.—When loss of water is of no consequence, a considerable expense is sometimes saved by placing the locks close together, without any intermediate pond; for by passing from one immediately into the other, there is only required one pair of gates more than the number of locks so connected, besides a proportionate saving of masonry. Thus, eight connected locks would only require nine pairs of gates; whilst, if they were detached, they would require sixteen pairs. But to show that these cannot be adopted with propriety excepting where water is abundant, it is necessary to observe, that every two alternate ascending and descending vessels will require as many locks-full of

water as there are locks: for instance, if a vessel has just ascended, it has left all the locks full; a descending vessel then enters the upper lock, and when its gates are closed, the water is run down; but all the locks below being previously filled, they cannot contain it, and it consequently passes over the gates or weirs of all of them into the lower canal: the vessel has by this means descended to the level of the second lock, the water in which must also be run into the lower canal, for the same reason as already stated. When the water of all the locks has thus been run down, an ascending vessel will require all these locks to be filled from the upper canal, which, however, will be retained in the locks ready for the succeeding vessel to pass down. From this it will be evident, that where eight locks are connected, a descending vessel draws no water from the upper canal, because the locks are previously all filled, but it empties eight locks of water into the lower canal: an ascending vessel, on the contrary, empties no water into the lower canal, because all the locks were previously emptied, but it draws eight locks-full from the upper canal, in order to fill them: consequently, the passing of one ascending vessel, and one descending, requires eight locks-full of water.

Other modes of passing vessels from one level to another, by substituting machinery, either wholly or in part, have been adopted; but these have either failed entirely, or have not been brought into general use.

Locomotive Steam Engines, a class of travelling machines adapted either for railways or common roads, were originally designed for the latter, but did not succeed; and roads were then made for them, called railways, on which they have been most successful. The principle of action being the same in both kinds, a description of the railway variety will explain the manner in which progressive motion is obtained by the agency of steam.

Locomotion or progression is the combined effect of a number of parts in each engine performing separate duties. The principal of these parts and the plan of their co-operation may be thus classed:

1st. The parts which generate the steam.
2nd. The parts which regulate the employment of the steam.
3rd. The parts by which the driver controls the action of the engine.
4th. The parts immediately concerned in producing locomotion.
5th. The parts which excite the rapid combustion of the fuel.
6th. The parts which supply water to the boiler.
7th. The parts which support the engine on the rails.
8th. The manner in which locomotion is produced by these parts.

In explaining them and their effect as thus arranged, we have

1st, The parts which generate the steam, called the boiler, containing internally a fire-box, varying according to the dimensions of the engine from 25 (as in the 'Rocket') to 303 small tubes (as in the broad-gauge engines), a regulator, and a steam-pipe. Externally, a chimney and two safety-valves are fixed to the boiler.

2ndly, The parts which regulate the employment of the steam are, two slide-valves (covering the passages to and from the cylinders), attached to two sets of 'valve-gear,' worked by two eccentrics for the 'forward' and two other eccentrics for the 'backward' motion of the engine; but only two of them work at one time, the other two being what is called 'out of gear.' Four rods called eccentric-rods, encircling the eccentric-sheaves at one end, and jointed to the slide-valve gear at the other end, complete the con-

nection of the slide-valves to the eccentrics fixed on the axle of the driving wheels.

3rdly, The parts by which the driver controls the action of the engine are, three sets of levers and rods connected to the slide-valve, eccentric-rods, regulator-valves, and feed-pipe cocks, whereby he can 'put on' or 'shut off' steam to the cylinders, water to the boiler, or place the slide-valves in a 'forward' or 'backward' position at his pleasure. These arrangements are usually called the 'hand-gear.'

4thly, The parts immediately concerned in producing locomotion are, two cylinders, on which work two steam-tight pistons, fixed on the end of the piston-rods. On the open end of the piston-rods are also fixed T-pieces, called cross-heads, which slide between or round guide-bars, called motion-bars, fixed parallel with the cylinders. By this means the pistons can only move in a right line with the cylinders. Two strong rods, called connecting-rods, attach the cross-heads to the driving wheels, or to a cranked axle when there is one used. Whether the pistons are connected to a cranked axle or to the arms of the driving wheels, this connection is always made at an angle of 45 degrees to each other; therefore the one piston is in the centre of the cylinder exerting its greatest power during that part of the stroke when the other piston is at the end of the cylinder exerting no power. (This excellent arrangement was amongst the first improvements introduced by the late Mr. G. Stephenson, in 1814, who thus placed the locomotive in the same high position, as to efficiency, as was previously done for fixed engines by Watt.) The connection being thus completed between the pistons and the driving wheels, it is evident that any *movement of* the one must immediately act upon the other.

5thly, The parts which excite the rapid combustion of the fuel required in locomotive engines are, the chimney and a pipe called the blast-pipe, so made as to cover the exhausting passages from both cylinders, and terminating in the centre of the chimney, near the level of the top of the boiler. It is the escape through this pipe of each succeeding cylinder-full of steam, or that portion of it allowed to escape by the slide-valves, which causes the 'beats' or 'pulsations' so distinctly audible when the locomotive is at work.

6thly, The parts which supply water to the boiler are, two force-pumps, connected by two feed-pumps to the boiler, and to a reservoir of water. The pumps are worked either from the cross-head, or from eccentrics on the axle of the driving wheels.

7thly, The parts which support the engine are, 2, 4 or 6 wheels, besides the driving wheels, a set of springs, and a strong frame on which the boiler and machinery are securely fixed.

8thly, The manner in which locomotion is produced from the co-operation of these several parts is as follows. The boiler is filled with water until it completely surrounds all the tubes and inside fire-box. Fire is then applied, and in due time steam is generated from the water and collected between the surface of the water and the top of the boiler, until it has reached the pressure required. On the regulator being then opened, and the slide-valves placed in their working position by the driver, the steam passes from the boiler through the steam-pipe to the cylinders, where its force moves the pistons, which, being attached to the driving wheels (as has been explained), causes them to revolve, and thus produces locomotion. The slide-valves and pumps being wrought from some part set in motion by

the piston, regulate the admission of steam to the cylinder, and of water to the boiler. When the steam has moved the piston to the end of the cylinder, a passage is opened for its escape to the atmosphere through the blast-pipe, and the velocity of this escaping steam creates a partial vacuum in the chimney, causing a rush or 'blast' of air through the fire to fill this vacuum; which blast excites the rapid combustion of the fuel, and consequent rapid generation of steam. This completes the duties of one admission of steam to the cylinders, until its escape to the atmosphere; and when this escape has taken place, another admission of steam, to the opposite side of the piston, forces it back to the other end of the cylinder; and by the medium of the crank, the reciprocating motion of the piston is converted into a rotatory one, and the locomotion begun by the first admission of steam to the cylinders is continued by the second and succeeding admissions.

The repetition of these simple operations has amazed and gratified the world, by safely conveying heavy passenger trains at upwards of 70 miles an hour, and merchandise trains of 600 tons weight, at 25 miles per hour!—the mere idea of which, not many years since, would have been regarded as purely fabulous.

Such is the modern railway locomotive,—an illustrative example of the genius of man; but, like other important inventions, it is the joint production of many minds, and many more are still directed to its further improvement. The records of the Patent Office show, that from January, 1840, to the end of September, 1849, no less than 226 patents were enrolled, all of them more or less applicable to the steam engine and its appendages. Of these 226 patents, 45 were enrolled during the first nine months of 1849. It has been remarked that steam engines and railways were too matter-of-fact subjects for poets and painters; but from the above record it is evident that they deeply impress themselves upon the inventive intellect of the world; and if the prodigies performed by steam remain unsung or unportrayed, they dare, if not realize, the very sublimity of both poetry and painting; for what more interesting scene to delineate than one of these stately machines moving safely along, at eagle-speed, the very élite of the land, (including even the Royal Family,) through districts rich in the historical associations of past ages, and still teeming with the works of nature and of art! Surely it cannot be that the subject is too lofty a one for poetical or pictorial illustration, for in greatness of idea lies the success of both.

A brief review of the progress of locomotive engines is all that can be here given. It is now (1849) about 2000 years since the powers of steam were recorded by Hero of Alexandria, but it is only 200 years (in 1650) since it was first usefully employed by the Marquis of Worcester. The first idea of using it for propelling carriages is generally ascribed to Dr. Robison, in 1759, when it was suggested by him to Watt, who included a steam carriage in his patents of 1769 and 1784, but never carried them out. In 1786, Oliver Evans, of Philadelphia, had clear perceptions of the advantages of applying steam to waggons, boats, and mills; but the want of friends and means compelled him to confine his exertions to steam mills. From 1802 to 1805, Trevithick applied steam carriages to both common roads and railways, with considerable success for first experiments; and his engine, with Stephenson's improvements, is now the modern locomotive. About the year 1803, it appears that a Mr.

Fredericks also made a steam engine for a silver mine in Hanover, which, in 1811, was employed to convey their Majesties and suite of Westphalia over the mineral railway at considerable speed. This was probably the first royal trip on a railway. From 1805 up to 1814, invention was directed to insure the adhesion of the wheels upon the rails; and many ingenious plans were tried, some of which succeeded well at slow speeds, but were not calculated for high velocities. In 1814, however, Mr. Blackett, of the Wylam Railway, reverting to Trevithick's plan, fully established the FACT, that on a level, or moderately inclined railway, the adhesion of a smooth iron wheel upon a smooth iron rail was sufficient to draw heavy loads. He tried both six and eight wheeled engines. In 1814, Mr. Stephenson introduced two cylinders, or two complete steam engines, to one locomotive. From this time up to 1829, the powerful opposition of the owners of other modes of conveyance greatly retarded the progress of the locomotive engine; and so strong was the feeling that they were not economical, that both Mr. Walker and Mr. Rastrick reported against them, in 1829. These reports, and one of a doubtful character by Telford, led to the offer of a prize of £500, in 1829, by the directors of the Liverpool and Manchester Railway, for the best locomotive engine, whose weight was not to exceed six tons. This proceeding gave an important impulse to locomotives, and ended in establishing their superiority over all other existing systems of travelling. Five competitors appeared, namely, Messrs. Stephenson, Erickson, Hockworth, Burstal, and Brandreth. The machinery of the two last were not suitable, and did not proceed to trial. Mr. Stephenson's 'Rocket,' Mr. Erickson's 'Novelty,' and Mr. Hockworth's 'Sanspareil,' were all tried, and the prize was fairly won by the 'Rocket,' which, after the trials were over, reached a speed of 35 miles per hour, and the 'Novelty' about 24 miles per hour.

The 'Rocket' embraced the firebox, tubes, and blast-pipe of the modern locomotive.

The 'Novelty' embraced the plan now much used on short lines, of carrying engine, fuel, and water, all on one frame.

The 'Sanspareil' embraced the blast-pipe of the modern engine, with the single returned tube of the older locomotives. From this it will be seen that this competition at once brought out the leading features which have since rendered the locomotive engine so popular throughout the world.

From 1830, up to the introduction of the 7-feet gauge on the Great Western Railway, in 1838, no marked improvement took place in the locomotive, but the rivalry which sprung up between the gauges served greatly to develop their capabilities.

Engines of a novel construction, having the boiler on one frame, and the machinery on another frame, were tried on the Great Western Railway; also engines embracing Trevithick's plan of working the driving wheels by toothed wheels, fixed on a separate cranked axle, were tried, but all abandoned for engines modelled from one of Stephenson's; and the last new Great Western engines only follow up his latest improvements and Gray's expansive slide-valve motion on a large scale.

A number of patents have been enrolled for improving the locomotive engine, but a few only have been reduced to practice.

Amongst the more conspicuous of them are, Mr. Stephenson's improvements in the slide-valve motion; Mr. Gray's expansive motion; Mr. Crampton's arrangement

of wheels; Mr. Bodmer's arrangement of four pistons in two cylinders; Mr. M'Connell's tank engine; Mr. Samuel's express engine; and Mr. Adam's steam carriage. The improvements in the mechanism of the slide-valve motion, by Messrs. Stephenson and Gray, have been widely adopted. Mr. Crampton has engines of his plan at work both in England and on the Continent, which enable high driving wheels to be used on the narrow gauge, without raising the centre of gravity. (For an illustration of these and other examples, see the new edition of 'Tredgold on the Steam Engine.')

Mr. Bodmer's plan is to admit the steam between two pistons in one cylinder acting on two cranks, so as to compensate the strain on the frame and machinery. His engines work steadily, and are ingenious in construction.

The Tank engine carries on the same frame water and fuel, its tank for water being placed on the top of the boiler. This is the plan adopted on the Great Western Railway; but on narrow-gauge lines the tank is usually placed below the boiler and framing,—a better arrangement, where the machinery permits it to be done.

Mr. Samuel's express engine weighed only 25 cwt., and conveyed seven passengers at the rate of 30 miles per hour on the Eastern Counties Railway.

Mr. Adam's steam carriage is on this plan, with a very handsome carriage for passengers, all on one frame, and has been tried on some of the branch railways of both gauges.

Having thus briefly glanced at the progress of the locomotive engine, it only remains as briefly to notice some important discussions which have agitated the mechanical world regarding them.

From the earliest introduction of locomotives, four, six, or eight wheels appear to have been used, according to the designs of the makers; but about 1840–1–2, an animated discussion of the respective merits of the four and six wheeled engines was carried on in the columns of the railway press. Both classes have their merits, and both classes had able advocates, but public opinion evidently tended in favour of the six-wheeled engine as the safer of the two under all contingencies: hence the greater proportion of the present locomotives have six wheels.

The gauge controversy of 1845–6–7–8 led to the re-introduction of eight-wheeled engines on both gauges, weighing about 36 tons each, which realized speeds of about sixty and seventy miles per hour. The weight of these monster engines, it will be observed, is more than eight times that of the 'Rocket' (4¼ tons), which won the prize in 1829, whilst the speed is only twice that of the 'Rocket' (thirty-five miles) at that time. It is worthy of remark, that in 1829 the existing engines of 10 to 16½ tons were considered as far too heavy, and the Liverpool and Manchester directors bound competitors not to exceed six tons weight. In 1849, the same feeling prevailed, and the injury done to the railway by these 36 tons engines is much complained of, and tank engines and steam carriages embody this feeling in practice.

A description of the locomotive can scarcely be closed without noticing the death of its great improver, Mr. G. Stephenson, who died in 1848, aged 68 years.

He found the locomotive a very imperfect machine; he left it in that efficient state that even the daring genius of a Brunel could only copy his plans for the 7-feet gauge. This is another testimony to that far-seeing intellect which so early grasped the principal requisites for an efficient locomotive, and whose genius coped with and overcame the leading engineers of England,

in 1829, by establishing both locomotives and the Liverpool and Manchester Railway against all opposition, and from which sprung that system of railways which has added so immensely to the resources of the nation—ay, of the world.

Civil services, military services, naval services, and no services, have at all times been liberally rewarded by the Crown and Legislature; but there are no such rewards, no ORDER OF MERIT for such men as Stephenson, Watt, Arkwright, &c., who are the mainstays of our progress, our greatness, and our power. This is wrong—very wrong, and ought to be amended. However, if the Crown forget, and the Legislature neglect such men, it is consolatory to know, that their names will be embalmed in the hearts of the people, whilst the profligacy of honours and rewards to those having no real claim on the gratitude of the nation is universally condemned.

Upon the Taunus Railway, an apparatus is in use, invented by Mr. Thorman, which, from its simplicity and efficiency, cannot easily be excelled. It is attached to the hinder part of the tender, and is used in case of emergency, as well as being constantly used when at the stations, where it is necessary to uncouple the engine and tender from the train, thereby saving great trouble, and with less danger to engine-men and fire-men, as they can disconnect at any speed or at any time, whether the engine and train are in motion or not. (For a better elucidation of this simple and ingenious contrivance, see Thorman's work on the 'Taunus Railway,' 4to, 1846.)

Locker, a small closet or cupboard: lockers were used in churches to hold sacred relics

Locust-tree (the) of North America is *of a greenish* yellow; is tough and *durable, and* used for treenails for *ships, for posts*, stakes, paling, &c.

Lode, a metallic vein

Loft, a room in the roof of a building; a store-room in a theatre; a depository for hay and corn in a stable: a music loft; a singing loft; a rood-loft in a church

Lofty tin, rich, massive, and rough tin

Log, in navigation, a small triangular piece of board balanced by a thin plate of lead so as to swim perpendicularly, and, being fixed to a line, measures the ship's way

Logarithms are the artificial numbers used to facilitate or abridge arithmetical calculations, and may be considered as expressing the relation between an arithmetical and geometrical series of terms, or between ratios and the measures of ratios, and are the indices or exponents of a series of numbers in geometrical progression. The origin and nature of logarithms may be easily explained.

In arithmetical series the quantities increase or decrease by the same difference, but in a geometrical series they increase or diminish by a common measure. The first of the following lines exhibits an arithmetical progression; all the other lines are examples of geometrical progression.

1—0, 1, 2, 3, 4, 5, 6, 7, 8, 9.
2—1, 2, 4, 8, 16, 32, 64, 128, 256, 512.
3—1, 3, 9, 27, 81, 243, 729, 2187, 6561, 25683.
4—1, 10, 100, 1000, 10,000, &c.

Here consider the upper line as the index to all the rest; every term of it is the logarithm of a corresponding term in each of them; and it is evident that an infinitude of other lines, or any one of the same lines, varying the point of commencement, and containing numbers in geometrical progression, might be added, to all of which the same arithmetical series might furnish logarithms.

Logeum, the pulpitum or wooden stage of a theatre, placed upon the proscenium or permanent stage.

In the Greek theatre the pulpitum extended into the orchestra beyond the proscenium.

Logwood, from Campeachy, Jamaica, Honduras, &c., is largely used as a purple or dark red dye-wood

Lombardic Architecture, a style which immediately succeeded the decline of the Roman style

Lombardic School of Painting. The distinguishing characteristics of this school are, grace, an agreeable taste for design, without great correction, a mellowness of pencil, and a beautiful mixture of colours. Antonio Allegri, called Correggio, was the father and the greatest ornament of this school: he began by imitating nature alone, but as he was chiefly delighted with the graceful, he was careful to purify his design; he made his figures elegant and large, and varied his outlines by frequent undulations, but was not always pure and correct, though bold in his conceptions. Correggio painted in oil, a kind of painting susceptible of the greatest delicacy and sweetness; and as his character led him to cultivate the agreeable, he gave a pleasing, captivating tone to all his pictures.

London and Nottingham whites. The best of these do not differ in any essential particulars materially, nor from the white leads of other manufactories. The latter, being prepared from flake-white, is generally the grayest of the two. The inferior white leads are adulterated with whiting or other substances, which injure them in body and brightness, dispose them to dry more slowly, to keep their place less firmly, and to discolour the oil with which they are applied. All the above are carbonates of lead, and liable to froth or bubble when used with aqueous, spiritous, or acid preparations.

Longitude, length; the distance of any part of the earth, east or west, from London, or any other given place

Long timbers, in ship-building, those timbers in the cant bodies which reach from the dead-wood to the second futtock-head

Loobs, tin slime or sludge

Loof, in navigation, pronounced *luff*, a term applied when a ship going large before the wind, is brought close by the wind; to put the helm towards the lee-side

Loop-hole, a narrow opening or crenelle used in the battlements of the castles of the early English

Lord of the land or tree, in Cornwall, the person in whose land the mine is; therefore the part which he reserves to himself for liberty to work a mine in his land is the one-sixth, one-seventh, one-eighth, or any other proportion, free of expense, and called the 'dues' dish'

Louvre, a lantern; a turret on the roof of an ancient hall or kitchen for the escape of smoke and for ventilation, now made an ornamental and pleasing object

Lozenge, in geometry called a rhomb, and when the sides are unequal, a rhomboid; in heraldry, a four-cornered figure, resembling a pane of glass in old casements.

Lozenge moulding, a name given to the Norman style of mouldings and ornaments, which are shaped like lozenges

Lubricate, to make smooth or slippery

Lubricator, an oil-cup or other contrivance for supplying oil or grease to rubbing surfaces, in order to diminish friction

Lucerna, an oil-lamp. The Greeks and Romans originally used candles; but in later times these were chiefly confined to the houses of the lower classes

Lugsail, in navigation, a small sail hoisted occasionally on the mast of a boat or small vessel

Lychnus, a lamp suspended, or a pendent light

Lysis, some member above the corona of a podium, introduced in temples, and in the scene of a theatre

MAC MAC

MACHINÆ ORGANA, defined by Vitruvius, in his 10th book, as contrivances for the concentration and application of force, which are known by the names of instruments, mechanical powers, machines, engines, &c.

Machinery, a general term applied to mechanical combinations of parts for creating power, or producing works which may otherwise be, more or less perfectly, made with the hands. The first class of these combinations is usually distinguished by the name of engines; the second, by that of machines.

Engines, or machines for creating or accumulating and applying power, are distinguished from each other according to the material employed in the creation of their power, as air-engines, water-engines, gas-engines, steam-engines, electric-engines, &c.

Machines employed in the manufacturing arts are named according to their products, as lace-machinery, rope-machinery, paper-machines; or to the processes they perform, as spinning-machinery, printing-machinery, sawing-machinery, &c.

The materials of which machinery is composed are, wood of various kinds, iron, brass, copper, and other metals, with flexible materials for bands, cords, &c., as wool, caoutchouc, and leather.

The several parts of machinery are, frames, plummer-blocks, carriages, bolts and nuts, pins, shafts, wheels, pinions, levers, cranks, springs, screws, pulleys, riggers, bands or belts, and cords, &c., studs, tappets, wedges, rods, cylinders, tubes, pistons, valves, buckets, floats, weights, beams, racks, chains, clutches, winches, &c.

The power of engines, as distinguished from machines, depends upon the nature of the material from which their power is gathered. The mere mechanical effect of every piece of machinery is calculable upon its combinations of certain elementary forms, commonly termed the mechanical powers, with deductions from the effect of these for friction between the parts, for rigidity of parts which are theoretically supposed to be perfectly flexible, and for the elasticity of parts which are supposed to be perfectly rigid.

The mechanical powers, sometimes described as six in number, viz. the lever, the wheel and axle, the pulley, the inclined plane, the wedge, and the screw, are reducible to two only, viz. the lever and the inclined plane, in each of which the effect produced is just as many times greater than the power employed, as the space through which the power moves is greater than the space through which the effect is continued. Thus, if with a lever a weight be raised ten times greater than the weight or power by which it is raised, this weight or power will have to move through ten times as much space as the height through which the greater weight is raised.

Propriety of form in the detail of machinery depends upon two circumstances. The first is, that the parts subject to wear and tear, and influenced by strains, should be capable of motion or adjustment: the second, that every portion should be equally strong, and present to the eye a uniform figure, or one that is consistent with its degree of action: theory, practice, and taste, all must combine to produce such. A great extent of beauty is attainable in all the details, but mathematical reasons cannot be given why a certain arrangement of lines should be preferable to another, provided

they are equally strong. Truth does not strike us without the assistance of custom; but so great is the force of custom, that unassisted by truth it has worked the greatest miracles; and it certainly must be this universal Mentor which gives us the power to choose between forms.

Macellum, a market-place for all kinds of provisions

Maceria, a rough wall

Machicolations, openings formed for the purpose of defence at the top of castles and fortifications, by setting the parapet out on corbels, so as to project beyond the face of the wall

Madder carmine, or *Field's carmine*, is, as its name expresses, prepared from madder. It differs from the rose lakes of madder principally in texture, and in the greater richness, depth, and transparency of its colour, which is of various hues, from rose colour to crimson

Madder orange, or *Orange lake*, is a madder lake of an orange hue, varying from yellow to rose colour and brown

Madder purple, *Purple rubiate*, or *Field's purple*, is a very rich and deep carmine, prepared from madder. Though not a brilliant purple, its richness, durability, transparency, and superiority of colour, have given it the preference to the purple of gold purple, and to burnt carmine.

Madder yellow is a preparation from the madder root. The best is of a bright colour, resembling Indian yellow, but more powerful and transparent, though hardly equal to it in durability of hue; metallic, terrene, and alkaline substances acting on and reddening it as they do gamboge: even alone, it has by time a natural tendency to change in appearance.

Mæniana, seats in the upper porticoes of the Roman forum, from whence spectators witnessed the combats of gladiators

Magnase black is the best of all blacks for drying in oil without addition, or preparation of the oil: it is a colour of vast body and tingeing power

Mahogany is a native of the West Indies and the country round the Bay of Honduras. It is said to be of rapid growth, and so large that its trunk often exceeds 40 feet in length and 6 feet in diameter. Spanish mahogany is imported from Cuba, Jamaica, Hispaniola, St. Domingo, and some other of the West India Islands, in logs from about 20 to 26 inches square and 10 feet long. It is close-grained and hard. There is also African mahogany. All the species are used for many purposes, more particularly for superior household furniture.

Main links, the links in the parallel motion which connect the piston-rod to the beam of a steam engine

Malleable, in metallurgy, capable of being spread by heating or by rolling,—a distinguishing character of metals, but more especially of gold. When flattened, it is said to be laminable; when drawn as wire, ductile.

Manacaybo is a furniture wood of moderate size, hard, as good as mahogany, and in appearance between that and tulip wood

Manchineel, a large tree of the West Indies and South America: it possesses the general character of mahogany, but has a poisonous and unwholesome sap

Mandril, the spindle which carries the centre-chuck of a lathe, and communicates motion to the metal to be turned: in small lathes it is driven by a pulley

Mandril-frame, the head-stocks or frame bolted to the end of a lathe-bed, for the purpose of supporting the mandril

Mangrove, an aquatic tree, straight-grained, hard, and elastic: much used for ship-building

Man-hole, in locomotive engines, an opening in the top of a boiler, used

as an entrance when the boiler requires cleaning: it is covered by a strong plate bolted to the boiler plating, so as to be steam-tight

Man-hole cover, in locomotive engines, a strong plate of iron, bolted over the man-hole so as to be removeable when required

Manipulation, in mining, the manner of digging silver or other metals; a term now generally applied to the means by which materials or effects are produced

Manner is that habitude which painters have acquired, not only in the management of the pencil, but also in the principal parts of painting, —invention, design, and colouring. It is by the manner in painting that a picture is judged to be by the hand of Titian, Tintoret, Guido, the Caracci, and others. Some masters have had a variety in their manners at different periods of life, and others have so constantly adhered to one manner, that those who have seen even a few of them will immediately know them, and judge of them without any risk of a mistake. The variety observable among artists in their manner and taste arises from the practice of the different schools in which they have received their instruction, or of the artists under whom they have studied. Yet there are many instances of great artists who have divested themselves of that early partiality to a peculiar manner, and have altered it so effectually as to fix on one abundantly more refined and better adapted to their peculiar genius, by which means they have arrived at excellence. Thus, for instance, Raphael proceeded, and acquired a much more elevated manner after he had quitted the school of Perugino.

Mannerist, a term applicable to a painter whose pictures have no resemblance to the beautiful varieties of nature, but discover an unpleasing and tasteless sameness

Manometer, an instrument intended to measure the rarefaction and condensation of elastic fluids in confined circumstances, whether occasioned by variation of temperature or by actual destruction, or generation of portions of elastic fluids

Mansard roof, of French origin, from the name of the inventor; a curb roof

Manse, a parsonage-house

Mantel-piece, a beam across the opening of a fire-place, serving as a lintel or bressummer to support the masonry above, which is called the chimney-breast

Maple wood is considered to be allied to the sycamore or the plane-tree; its colour is pale: much used for picture frames and Tunbridge ware

Marble, a kind of stone found in great masses, and dug out of pits or quarries

Marcus, a large iron-headed hammer

Market. The market or forum in the cities of antiquity was different from the market in our English towns, where flesh meat, merchandise, &c., are usually sold. The Apostle Paul disputed with philosophers in the market at Athens: this and other evidences prove it to have been also a place of disputation and public resort.

Margin or *Lock-rail*, the flat part of the stile and rail of framed work

Marine engine, a steam engine to propel a ship. There are various kinds of them, the beam, direct-acting, oscillating, &c. (See Tredgold's work.)

Marline, a small line used for winding round ropes and cables

Marone is of a class of impure colours, composed of black and red, black and purple, or black and russet pigments, or with black and any other denomination of pigments in which red predominates

Marone lake is a preparation of madder, of great depth, transparency, and durability of colour: it works well in water, glazes and dries in oil, and is in all respects a good

pigment: its hues are easily given with other pigments, but it is not much used

Marquetry, chequered or inlaid work; work inlaid with variegation, a sort of veneering, representing flowers, birds, and other figures

Masonry. The early Roman architecture, both in public and private buildings, was of far more durable materials and of more accurate masonry than such as was executed in the decline of the empire. It began to be uncemented blocks of stone, passed into the reticular work of the republic, thence into the travertine, and descended into the mixture of tufo, and brick, and stucco facing.

Masonry. Marble is polished by being first rubbed with grit-stone, afterwards with pumice-stone, and lastly with emery or calcined tin. Marbles, with regard to their contexture and variegation of colour, are almost infinite: some are black, some white, and some of a dove colour: the best kind of white marble is called statuary, which, when cut into thin slices, becomes almost transparent, which property the other kinds do not possess. Other species of marble are streaked with clouds and veins. The texture of marble is not altogether understood, even by the best workmen; but they generally know upon sight, whether it will receive a polish or not. Some marbles are easily wrought, some are very hard, other kinds resist the tools altogether. Artificial marble, or Scagliola, is real marble pulverized and mixed with plaster, and is used in columns, basso-relievos, and other ornaments.

The chief kind of stone used in London is Portland stone, which comes from the island of Portland, in Dorsetshire; it is used for buildings in general, as strings, window-sills, balusters, steps, copings, &c., but under great weight or pressure it is apt to splinter, or flush at the joints. When it is recently quarried, it is soft and works easily, but acquires great hardness in course of time. St. Paul's cathedral and Westminster bridge are constructed of Portland stone.

Purbeck stone comes from an island of the same name, also in Dorsetshire, and is mostly employed in rough work, as steps and paving.

Yorkshire stone is also used where strength and durability are requisites, as in paving and coping.

Ryegate stone is used for hearths, slabs, and covings.

Mortar is used by masons in cementing their works. (See *Bricklaying*, *Cements*, *Mortars*, &c.) In setting marble or fine work, plaster of Paris is used, and in water-works, tarras is employed.

Tarras is a coarse mortar, durable in water, and in most situations. Dutch tarras is made of a soft rock-stone, found near Cologne, on the Rhine. It is burnt like lime, and reduced to powder by mills, from thence carried to Holland, whence it has acquired the name of Dutch tarras. It is very dear, on account of the great demand for it in the construction of aquatic works.

An artificial tarras is formed of two parts of lime and one of plaster of Paris: another sort consists of one part of lime and two parts of well-sifted coal ashes.

Mast carlings, in ship-building, large timbers at the side of the mast rooms that are left deep enough to receive the cross-chocks

Mastic, a cement used for the plastering of walls

Mastic varnish is easily prepared by digesting in a bottle, during a few hours, in a warm place, one part of dry picked resin with two parts or more of the oil of turpentine

Materiatio, according to Vitruvius, the timber-work of a roof

Mathematics, a science which teaches to number and measure whatever is capable of it, comprised under lines, numbers, superficies, or solids

Matter and Motion. Quantities of

matter in all bodies are in the compound ratio of their magnitude and densities; for if the magnitudes are equal, the quantities of matter will be as the densities; and if the densities are equal, the quantities of matter will be as the magnitudes: therefore, the quantities of matter are universally in the compound ratio of both.

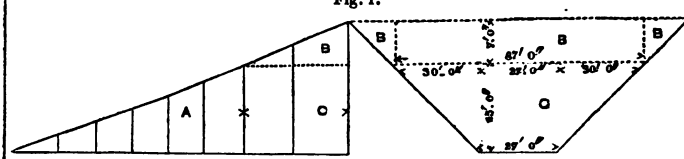
Mausoleum, a pompous funereal monument, a costly sepulchre

Maximum and *minimum*. The extremes of temperature are no less important to the meteorologist than interesting to the general observer. They are obtained by the self-registering thermometer. The first instrument of this kind was suggested by John Bernouilly. Several forms of thermometers were communicated to the Royal Society by Lord Charles Cavendish. The next in point of time were the contrivances of Fitzgerald and Crighton. Six, Rutherford, Keith, Blackadder, and Dr. Trail, greatly added to the stock of self-registering thermometers. There are two kinds in general use; Mr. Six's, which is placed vertically, and Dr. Rutherford's, which is suspended horizontally. The latter is preferable on land, and, from its simplicity, has to a certain extent superseded the former.

Mear, thirty-two yards of ground in a vein of ore

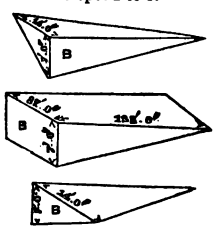
Measurement of earth-work. There are many works and tables published to facilitate the admeasurement of earth-work, which may be reduced in practice to the following geometrical forms, in one or more chains in length, as the case may be. The two chains marked B and C in the section will reduce to the forms in the diagrams that follow. The dotted lines, fig. 1, show the section at the largest end, next to B in the section; and the dotted line, fig. 2. shows the section at the smallest end, next to A in the section.

Fig. 1.



The bottom piece, C, being reduced to a parallel throughout, is measured by multiplying the area of

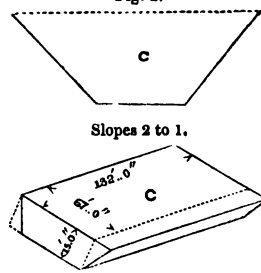
Slopes 2 to 1.



the end by the length: the two banks being equal, it will measure *thus:* 15′ 0″ × 57′ 0″ × 132′ 0″.

The piece B, the middle or wedge piece, being parallel horizontally only, is measured by taking one-

Fig. 2.



Slopes 2 to 1.

half the vertical height: thus, 3′ 6″ × 87′ 0″ × 132′ 0″.

The two pieces B B form the two halves of a right-angled pyramid, and are measured by multiplying the area of the end by one-third the height: therefore 7′ 0″ × 14′ 0″, the slope being 2 to 1, is equal to 98′ 0″; the area of the two bases then, 1′ 0″ × 98′ 0″ × 44′ 0″, gives the cube quantity in the two.

Measurement of shipping for tonnage (called the 'new measurement') was regulated in the 5th and 6th of George IV. By this Act certain rules were established for ascertaining the tonnage of ships, as well on shore as afloat, and of vessels propelled by steam; and the account of such tonnage, whenever the same shall have been ascertained according to the rules herein prescribed, (except in the case of ships admeasured afloat,) it is enacted, shall be deemed the tonnage of such ships, and shall be repeated in every subsequent registry of such ships, unless any alteration shall have been made in their form and burthen, or unless it be discovered that the tonnage had been erroneously computed: and it is considered that the capacity of a ship is the fairest standard by which to regulate its tonnage; that internal measurements will afford the most accurate and convenient method of ascertaining that capacity, and that the adoption of such a mode of admeasurement will tend to the interests of the ship-builder and the owner.

It was enacted that the tonnage of every ship or vessel required by law to be registered shall, previous to her being registered, be measured and ascertained while her hold is clear, and according to the following rule: Divide the length of the upper deck between the after-part of the stem and the fore-part of the stern-post into six equal parts. Depths: At the foremost, the middle, and the aftermost of those points of division, measure in feet and decimal parts of a foot the depths from the under side of the upper deck to the ceiling at the limber strake. In the case of a break in the upper deck, the depths are to be measured from a line stretched in a continuation of the deck. Breadths: Divide each of those three depths into five equal parts, and measure the inside breadths at the following points: at one-fifth and at four-fifths from the upper deck of the foremost and aftermost depths, and at two-fifths and four-fifths from the upper deck of the midship depth. Length: At half the midship depth measure the length of the vessel from the after-part of the stem to the fore-part of the stern-post, then to twice the midship depth add the foremost and the aftermost depths for the sum of the depths; add together the upper and lower breadths at the foremost division, three times the upper breadth and the lower breadth at the midship division, and the upper and twice the lower breadth at the after division, for the sum of the breadths; then multiply the sum of the depths by the sum of the breadths, and this product by the length, and divide the final product by three thousand five hundred, which will give the number of tons for register. If the vessel have a poop or half-deck, or a break in the upper deck, measure the inside mean length, breadth, and height of such part thereof as may be included within the bulkhead; multiply these three measurements together, and dividing the product by 92·4, the quotient will be the number of tons to be added to the result as above found. In order to ascertain the tonnage of open vessels, the depths are to be measured from the upper edge of the upper strake.

To ascertain the tonnage of steam vessels, it was also further enacted, that in each of the several rules prescribed, when applied for the purpose of ascertaining the tonnage

of any ship or vessel propelled by steam, the tonnage due to the cubical contents of the engine-room shall be deducted from the total tonnage of the vessel as determined by the rules, and the remainder shall be deemed the true register tonnage of the said ship or vessel. The tonnage due to the cubical contents of the engine-room shall be determined in the following manner: measure the inside length of the engine-room in feet and decimal parts of a foot from the foremost to the aftermost bulk-head, then multiply the said length by the depth of the ship or vessel at the midship division, as aforesaid, and the product by the inside breadth at the same division at two-fifths of the depth from the deck taken as aforesaid, and divide the last product by 92·4, and the quotient is deemed the tonnage due to the cubical contents of the engine-room.

Measurement of standing timber.—Measure from the tree ten, twenty, thirty, &c., feet, and then plant the theodolite level: direct the telescope to the bottom of the tree, and observe the degree and tenth of depression; and to the top of the tree, the degree and tenth of elevation. When the timber has been previously felled, it is customary, in measuring, to girt a string round the middle of the tree, and fold it twice, which will give the fourth part of the girt, and which is considered the true side of the square; then the length is measured from the but-end of the tree, so far up as the tree will hold half a foot girt, or, more properly speaking, quarter-girt; that is, the line six inches when twice folded. Various tables are published, to assist the timber-measurer in the performance of his duty. All timber is bought and sold by the load, and a load is estimated at forty feet of unhewn or rough timber, *and fifty feet of* hewn timber, which is supposed to weigh one ton, or twenty hundred weight.

Mechanical powers are contrivances by which we are enabled to sustain a great weight or overcome a great resistance by a small force. (See *Machinery*.)

Mechanics, that branch of practical science which considers the laws of equilibrium and the motion of solid bodies; the forces by which bodies, whether animate or inanimate, may be made to act upon one another; and the means by which these forces may be increased so as to overcome those which are more powerful. The term mechanics was originally applied to the doctrine of equilibrium. It is now, however, extended to the motion and equilibrium of all bodies, whether solid, fluid, or aëriform. The complete arrangement of mechanics is now made to embrace, besides, the pressure and tension of cords, the equilibrated polygon, the catenary curve, suspension bridges, the equilibrium of arches and the stability of their piers, the construction of oblique arches, the equilibrium of domes and vaults with revetments, the strength of materials, whether they be of wood or iron, dynamics, or the science of moving bodies, with hydrostatics, pneumatics, and hydraulics.

Medallion, in architecture, any circular tablet on which figures are embossed; busts, &c.

Mediæval, relating to the middle ages

Member, a moulding; either as a cornice of five members, or a base of three members, and applied to the subordinate parts of a building

Mensuration is the application of the science of arithmetic to geometry, by which we are enabled to discover the magnitude and dimensions of any geometrical figures, whether solid or superficial. To enable us to express this magnitude in determinate terms, it is necessary to assume some magnitude of the same kind as the unit, and then, by

END OF PART II.

stating how many times the given magnitude contains that unit, we obtain its measure.

The different species of magnitude which have most frequently to be determined are distinguishable into six kinds, viz. 1. Length. —2. Surface.—3. Solidity, or capacity.—4. Force of gravity, commonly called weight.—5. Angles. —6. Time.

Mere, or *Meer*, a name frequently given, in England and the Netherlands, to inland lakes or sheets of fresh water, such as Windermere, Whittleseamere, Ugg-mere, Soham-mere, in England, and the Egmonder meer, Purmer meer, and Haarlemmer meer, &c., in the Netherlands. The term is most frequently used in the latter country, where, prior to 1440, there were more than 150 meers, of which 85 occupied an area of 177,832 acres, since drained and reclaimed, in the provinces of North and South Holland; and where also the Haarlemmer meer, covering an area of 45,230 acres, is now in course of drainage.

As the meers, in fen-lands, serve as reservoirs to hold a portion of the surplus rain-water falling on the district of which they form a part, their being dyked off and drained, where of considerable extent, has most important effects on the neighbouring lands, by contracting the area of the reservoir or catch-water basin of the district. But as these drainages generally oblige improvements in the outfalls, their result is mostly beneficial to the other lands.

The beds of the Dutch meers are from 10 to 20 feet below the level of the lowest point of the natural outfall in their districts; consequently they are always drained by mechanical means. Wind-mills have been employed to drain the land, in the Netherlands, from time immemorial; but the drainage of the meers was not commenced until 1440, about which period wind-mills and draining machinery were considerably improved; and as late as 1840, wind-mills for draining purposes continued in favour with the Dutch engineers, in preference to steam engines; and at that date, 12,000 wind-mills were employed to drain the polders, in the Netherlands, and only five small steam engines, the largest not exceeding 30-horse power: the average consumption of fuel was 20 lbs. of coal per horse power per hour.

In the English fens, steam had in a great measure superseded wind-mills for drainage purposes; but the consumption of fuel was nearly as great as in the Dutch engines.

In 1839, the Dutch States-General decreed the drainage of the Haarlemmer meer, and voted eight millions of florins for that purpose, to which two millions more were subsequently added, making the total sum of £834,000.

The Haarlemmer meer forms part of the great drainage district of Rhynland, which has an area of 305,014 English acres: prior to 1848, this area was occupied by 56,609 acres of meers and water-courses, nearly all in communication with each other, forming what is called the *boezem*, or catch-water basin of the district; the surface of the water being maintained at the lowest level of natural sluiceage, by sluices at Katwyk into the North Sea, and at Sparndam and Halfweg into the Y, or the southern end of the Zuyder Zee.

Above the boezem are 75,357 acres drained into it by natural level; and at depths from 2 feet 6 inches to 4 feet *below* it are 170 polders covering an area of 135,850 acres; and 37,198 acres, divided into 28 polders which were formerly meers, but are now drained, and whose beds are on an average 14 ft. below the level of the boezem.

The surplus rain and infiltration

waters from the 173,048 acres of polder-land are lifted into the boezem by the united action of 261 large wind-mills, with an average force of 1500-horse power.

The drainage of the Haarlemmer meer, which forms part of the boezem or basin, will deduct 45,230 acres from its area, and reduce it to 11,379 acres, or ⅛th part of its former size; whilst the land surface drained into it will be increased from 229,657 to 293,735 acres.

The average level of the boezem is 10 inches below the ordinary low water, and 27 inches below high-water mark in the Y or Zuyder Zee; and 7 inches above low water, and 57 inches below ordinary high water, in the North Sea.

The bed of the Haarlem Lake is 14 feet below the winter level of the boezem; and when drained, the maximum lift will be 16 feet 6 inches to 17 feet, according to the state of the wind, which raises or depresses the surface of the water in the canals very considerably.

The water contents of the Haarlemmer meer to be pumped out, including the additional quantity arising from the surplus rain and infiltration during the draining, are estimated at 800,000,000 cubic mètres or tons.

The greatest quantity of monthly drainage when the meer is pumped out is estimated at 36,000,000 tons, and the annual average surplus of rain-water, &c. at 54,000,000 tons to be lifted, on an average, 16 feet high.

The Dutch engineers were generally in favour of wind-mills, or a combination of wind-mills and steam engines, for pumping out the meer; but in 1841, the late king, William II., by the advice of a commission, decreed that steam engines only should be employed for the purpose; and in 1842, at the suggestion of two English engineers, Mr. Arthur Dean and Mr. Joseph Gibbs, it was determined to erect, and they were directed to prepare the designs for, three steam engines upon the high-pressure, expansive, condensing principle, of the ordinary force of 350-horse power each, but capable of being worked on emergencies up to 500-horse power.

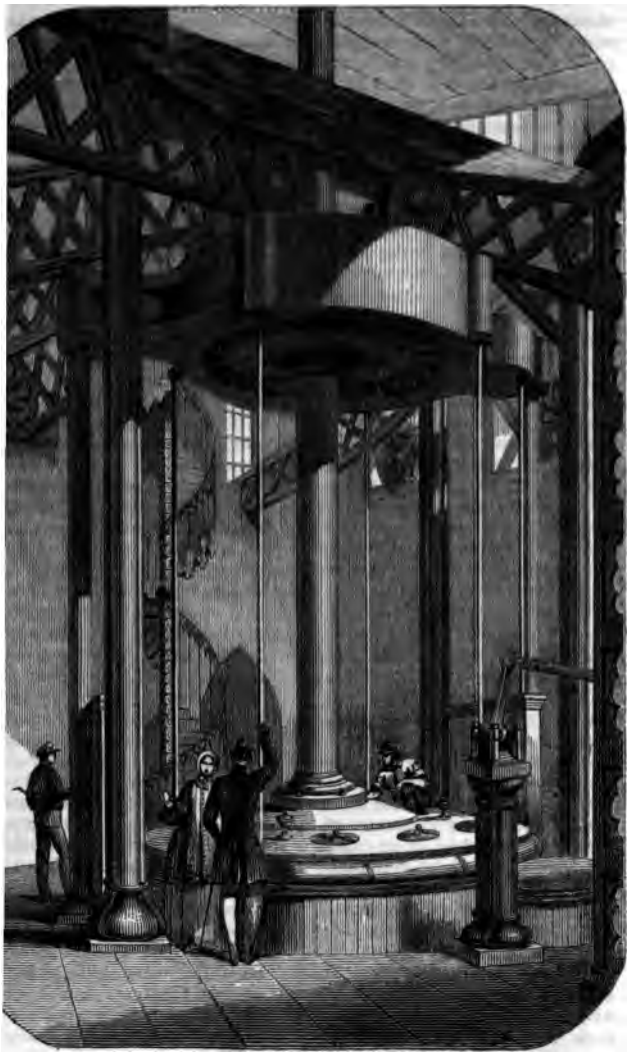
The consumption of fuel was limited to 2¼ lbs. of coal per horse power per hour.

The three engines were named the 'Leeghwater,' 'Cruquius,' and 'Lynden,' after three celebrated men who had at different periods proposed plans for draining the Haarlemmer meer.

The 'Leeghwater' was the first erected, to work eleven pumps of 63 inches diameter, with 10-feet stroke in pumps and steam cylinders; and the 'Cruquius' and 'Lynden,' were afterwards constructed, to work eight pumps each, of 73 in. diameter, and with 10-feet stroke; each engine is calculated to lift 66 cubic mètres or tons of water per stroke.

The accompanying sketch is a representation of the interior of the 'Lynden' engine and engine-house, on the upper floor: the 'Cruquius' is on the same model; but the 'Leeghwater' has the inner ends of its eleven pump-beams arranged under the great cross-head, instead of over it.

Each engine has two steam cylinders, placed concentrically, the one within the other, the outer of 12 feet diameter, and the inner one of 7 feet diameter: both are secured to one bottom, and covered by one cover, but the inner cylinder does not touch the cover within 1½ inch: there are two pistons, 26 inches deep, the compartments of which are fitted with cast-iron plates: the outer piston is annular, and has a packing on both sides: beneath this annular piston a constant vacuum is maintained when working: the two pistons are connected by five pis-



a-rods, as shown in the sketch, a great cross-head or cap, the *ole mass weighing about 85 tons, d by eight connecting-rods the cap* pistons are suspended from the inner ends of eight cast-iron balance-beams, to the outer ends of which are hung the eight pump-pistons;

the action of the engines is therefore very simple: the steam being applied under the inner piston, lifts both the pistons, the great cross-head, and inner ends of pump balance-beams simultaneously, and the pump-pistons descend at the same time: by an hydraulic apparatus attached to the great cross-head, the dead weight of the pistons, &c. is arrested at the point to which it has been thrown up by the steam, and time is given for the valves of the pump-pistons to close before the down-stroke of the steam-pistons is made; then, the equilibrium-valve being opened, the hydraulic apparatus is liberated at the same moment, and the steam passing from beneath the small piston, above both pistons, the pressure on both sides of the small one is equalized, whilst nearly two-thirds of the steam acts upon the annular piston against a vacuum, and in aid of the dead weight helps to make the down-stroke in the steam-cylinder, and the up-stroke in the pumps. The use of the two cylinders enables the engine-man, by judiciously altering the expansion in the small cylinder, to command his work at all times, without stopping the engine to take out, or put in, dead weight, as would be necessary for a single-acting one-cylinder engine, where dead weight only is used for lifting the water. It has frequently occurred that the load of an engine has been added to or diminished by 10 or 12 tons in the course of half an hour, by the action of gales of wind on the surface of the meer and boezem. Each engine has two air-pumps of 40 in. diameter, and 5-feet stroke. The steam is cut off in the small cylinder at from one-fourth to two-thirds of the stroke, according to the load; and after expanding through the remainder of the stroke, it is still further expanded in the large cylinder.

The anticipated economy in consumption of fuel has been realized: when working with the net power of 350 horses, the average consumption is 2¼ lbs. of best Welsh coals, or 75 millions duty with 94 lbs. of coal; and on a late trial, the 'Cruquius' and 'Lynden' engines were found to do a duty of 87 millions.

The whole cost of machinery, buildings, coals, and wages, to pump out the lake, will not exceed £150,000, whereas, by wind it would have cost £308,000, being a saving of £158,000; and there will also be a further economy upon the works in the bed of the lake, amounting to £40,000 more, so that the total saving by steam over wind will be £200,000, and three years' time.

To compensate the district of Rhynland for the loss of 45,230 acres of the boezem or catch-water basin, a steam engine of 200-horse power, driving 10 large scoop-wheels, has been erected at Sparndam to lift the boezem water over the tide in the Y, or base of the Zuyder Zee, where the rise is on an average only 17 inches. This engine has discharged 30,000,000 tons of water in fifteen consecutive days. When the state of the boezem permits the 'Leeghwater,' 'Cruquius,' and 'Lynden' engines to work freely, they discharge on an average 2,000,000 tons in twenty-four hours, and they are capable of doing this down to their full depth. In the month of June, 1849, the three engines discharged 60,000,000 tons water, and lowered the meer one foot; between the 1st of May and 1st of December they had lowered the lake 5 feet, and by the autumn of 1850, it is calculated the dry land will appear. (See *Table.*)

The 'Leeghwater,' 'Cruquius' and 'Lynden' engines were contracted for jointly by the Hayle and Perran Foundry Companies, Cornwall, and were manufactured and erected

, arranged chronologically, showing the Lakes, Meers, and Water-places ch have been drained by mechanical means, and converted into Fertile ds, in the Provinces of North and South Holland, in the Netherlands.

	NORTH HOLLAND.		Area drained in Eng. acres.	SOUTH HOLLAND.		Area drained in Eng. acres.
f	Name of Lake, Meer, or Water-place.	Location near.		Name of Lake, Meer, or Water-place.	Location near.	
	Nesch Meer	Wervershoofd	59			
	Burghornder Do.	Burghorn	684			
	The Zyp	Schagerbrug	19026			
	Egmonder Meer	Egmond	10080			
	Berger Do.	Bergen	1394			
	Daal Do.	Koedyk	285			
	Vrooner Do.	St. Pancras	246			
	Achter Do.	Alkmaar	78			
	Kooi Do.	Do.	33			
	Zwyns Do.	Oudorp	38			
	Boekeler Do.	Akersloot	745			
	Wog Do.	Spierdyk	1541			
.2	The Beemster	Purmerend	16369			
	The Weiringerwaard	Colkom	3979			
	.. ..	.. ..	..	Soetermeersche Meer	Soetermeer	1285
	Tjaarlinger Meer	Warmenhuizen	98			
12	Purmer Do.	Purmerend	6260			
	.. ..	.. ..	..	The Lisserpoel	Lisse	533
	Baarsdorper Do.	Berkhout	401	Hem Meer	Sassenheim	149
	The Enge Wormer	Near Wormemeer	241			
	The Hr. Hugowaard	Langendyk	6904			
	Broeker Meer	Broek & Water-land	638			
28	Belmer Do.	Monnikendam	310			
	Buiksloter Do.	Buiksloot	772			
	The Groot Waal	Berkhout	138			
	Wormer Meer	Gisp	3786			
29	.. ..	.. ..	..	Diemer Meer	Diemen	1575
	Benning Do.	Abbekerk	245			
	Harger & Pettemer Polder	Petten	987			
	The Tien Meeren	Haring Garspel	4647			
	The Drie Do.	Oud Garspel	730			
	Kley Meer	Koedyk	147			
	Kerk Do.	Do.	48			
	Deble Do.	Warmenhuizen	31			
	Greb Do.	Do.	201			
	The Vier Meertjes	Medenblyk	680			
	Braak Meer	Eerstwoude	69			
	Veenhuizer Do.	Veenhuizen	718			
	Schals Do.	Knollendam	145			
2	Schermer Do.	N.& S. Schermer	12938			
3	The Vier Meertjes	Obdam	142			
6	Berk Meer	Veenhuizen	596			
0	Kolk Do.	Lambert Schagen	220			
2	.. ..	.. ..	..	Slooter Meer		199
3	Star Do.	Oostgrafdyk	1447			
4	Noordeinder Do.	Graft	409			
5	*Sap Do.*	*The Ryp*	52			
6	.. ..	.. ..	..	The Wilde Veenen	Moerkapel	1322
7	.. ..	.. ..	..	Stom Meer	Aalsmeer	409

Date of Drainage.	NORTH HOLLAND—*continued.* Name of Lake, Meer, or Water-place.	Location near.	Area drained in Eng. acres.
1666	.. ..	.. ..	..
1668	.. ..	.. ..	..
1674	.. ..	.. ..	..
1700	.. ..	.. ..	..
,,	.. ..	.. ..	..
1715	.. ..	.. ..	..
1727	.. ..	.. ..	..
1736	.. ..	.. ..	..
1736-44	.. ..	.. ..	..
1741	.. ..	.. ..	..
1754-62	.. ..	.. ..	..
1758-59	.. ..	.. ..	..
1759-65	.. ..	.. ..	..
1760-62	.. ..	.. ..	..
1763-66	.. ..	.. ..	..
1764	.. ..	.. ..	..
1767-68	.. ..	.. ..	..
,,	.. ..	.. ..	..
1768-71	.. ..	.. ..	..
1772-77	.. ..	.. ..	..
1772-82	.. ..	.. ..	..
1773-80	.. ..	.. ..	..
1781-84	.. ..	.. ..	..
1782-89	.. ..	.. ..	..
1786-88	.. ..	.. ..	..
1788-91	.. ..	.. ..	..
1788-99	.. ..	.. ..	..
1790 / 1810	.. ..	.. ..	..
1797 / 1809	.. ..	.. ..	..
1798-99	.. ..	.. ..	..
1799 / 1801	.. ..	.. ..	..
1810	.. ..	.. ..	..
1820	.. ..	.. ..	..
1828-40	.. ..	.. ..	..
1842	.. ..	.. ..	..
1840-50	.. ..	.. ..	..
			98557

SOUTH HOLLAND—*continued.* Name of Lake, Meer, or Water-place.	Location near.	Area drained in Eng. acres.
Wassenarsche Polder	Rhynsaterwoude	2488
The Driemans Do.	Soetermeer	2013
Horn Meer	Aalsmeer	441
Binnenwegsche Polder	Zegwaard	2247
H. Geest Polder	Leyminden	384
Goger Do.	Alkemade	607
Katjes Do.	Zevenhuizen	772
The Starrevaarts Do.	Stompwyk	443
The Vier Ambachts Do.	Esselykerwoude	518
Vrieskoophche Do.	Vriezekoop	1325
Endragts Do.	Zevenhuizen	2473
Damhouder Do.	Stompwyk	949
Novider Plas	Hazerswoude	8415
Palenternsche Polder	Zegwaard	1279
Ouwendyksche & Boe Do.	Esselykerwoude	805
Bovenkerker Do.	Amstelveen	3412
Great and Little Kalkovensche Do.	Oudshoorn	1318
The Groote Do.	Soetermeer	1686
Do. Do.	Stompwyk	1178
Berkelsche Do.	Berkel	2171
Bleiswyksche Drainage	Bleiswyk	8299
Schiebroksche Polder	Schiebroek	1457
Veender en Lyker Do.	Alkemade	1373
Pynakerscke Do.	Pynacker	1270
Aarlanderveensche Do.	Aarlanderveen	1171
Zestienhovensche Do.	Overschie	1064
Schieveensche Do.	Overschie	654
Mydrechtsche Do.	Mydrecht	2622
Niewekoopsche en Zevenhovenesche Do.	Niewekoop	1571
Gnephoek en Vrowe Do.	Oudshoorn	254
Bieslandsche Do.	Nootdorp	333
Kleine Slarrevuartsche Do.	Leydschendam	23
Bylmer Meer	Weesp	1470
The Zuid Plas	Rotterdam	14820
Nootdorpsche Plas	Delft	2500
Haarlem Lake (not yet completed)	Amsterdam, Haarlem and Leyden	45230

In South Holland, acres	124505
In North Do. Do.	98557
Total Acres	223062

the direction of Mr. Arthur
; they have all worked during
· three months with only
) hours' stoppage.
nay be said in this instance,
utch have realised the fable
: 'Hare and the Tortoise:'—
40, the erection of a steam
: of 30 or 40-horse power,
ainage purposes, was thought
a bold step, whereas, under
ridance of English engineers,
ave dared, between 1840 and
to erect the most gigantic
machinery in the world.
) low lands of the Nether-
are divided into large drain-
stricts, which have been em-
d against the inroads of the
and river floods; and the va-
parts of a district are con-
l by what is called the *boezem*,
er-basin, or reservoir, formed
rivers, lakes, meers, or water-
having their origin in the
t, and serves to receive the
drained either naturally or
ially from the surrounding
The boezem is put into
unication with the exterior
of the rivers or sea by locks
uices. All lands in a given
ge district above the level of
ezem, and draining naturally
, are called 'boezem lands.'
nds lying below the boezem,
rained into it by machinery,
led polders. Of polders there
o kinds: the first are seldom
than 2 or 3 feet below the
of the boezem, which is em-
l above the natural surface
land: of such polders there
wards of 1000 in the pro-
of South Holland only; and
re kept dry by the aid of an
ase number of wind-mills. Of
cond class of polders there
in North Holland and 43 in
Holland, as recorded in the
ing Table, and these are works
midable character, being, for
st part, the beds of lakes, or
ent sheets of water, varying
in depth from 5 to 20 feet below the boezem, and requiring powerful machinery to pump them out in the first instance, and to maintain them dry afterwards; and as these lakes, &c., always form part of the boezem, or reservoir, of a much larger tract of land, their drainage frequently involves the construction of immense works, and seriously affects the prosperity of the whole district in which they are situate.

The preceding Table will, as an apt illustration of the subject of draining large districts, be found important in engineering history.

By the Table it will be seen that the North Hollanders had effected the drainage of nearly all their lakes, &c., as early as 1645, and they had then recovered 98,557 acres of land forming their beds; whereas the South Hollanders had in 1645 only drained five small lakes, whose area was only 3741 acres. It must be observed that the South Holland drainages are of a much more extensive character than those of North Holland, and the difficulties to be overcome were much greater; and last, but not least, the North Hollanders were much richer than their neighbours. Of the 223,000 acres of lakes, &c., recorded in the Table, upwards of 50,000 acres were formed artificially, by dredging the peat pulp to the depth of 10 or 20 feet, to serve as fuel for domestic purposes, &c.

Meridian, in astronomy, the line drawn from the north to the south, through the zenith, nadir, and poles, which line the sun crosses at noon

Merlon, the solid part of an embattled parapet, standing up between the embrasures

Merus, the plain surface between the channels of a triglyph

Mesaula, a passage, gallery, lobby; an entry or court

Mestling, brass ornaments; candlesticks; sacred utensils used in Anglo-Saxon times

Metallurgy, the art of working metals, invented by Tubal-Cain, B. C. 3608. "And Zillah also bare Tubal-Cain, an instructor of every artificer in brass and iron." (*Gen.* iv. 22.) In the earliest periods of history, mention is made of the excellence in working metals among the Egyptians. Some specimens of metal-work of an early date exist, and modern fashion has also produced some very elaborate examples.

Metals are elementary bodies capable of combining with oxygen; and many of them, during this combination, exhibit the phenomenon of combustion. Seven metals only were formerly known; but recently a much greater number has been been added. Metals are distinguished by their great specific gravity, considerable tenacity, and hardness, opacity, and property of reflecting the greater part of the light which falls on their surface, giving rise to metallic lustre or brilliancy. Metals are the best conductors of caloric: their expansibilities are various, and are probably nearly in the order of their fusibilities. Mercury melts at so low a temperature, that it can be obtained in the solid state only at a very low temperature; others, as platina, can scarcely be melted by the most intense heat which we can excite.

Metals employed in the mechanical arts:

ANTIMONY is of a silvery white colour, brittle, and crystalline in its ordinary texture: it fuses at about 800°: its specific gravity is 6·712.

BISMUTH is a brittle, white metal, with a slight tint of red: its specific gravity is 9·822: it fuses at 476°, and always crystallizes on cooling.

COPPER is the only metal, with *the exception of* titanium, which has *a red colour: it* has much lustre, *is very malleable* and ductile, and exhales a peculiar smell when warmed or rubbed: it melts at a bright red or dull white heat, or at a temperature intermediate between the fusing points of silver and gold = 1996° Fahr.: its specific gravity varies from 8·86 to 8·89,—the former being the least density of cast copper; the latter, the greatest of rolled or hammered copper.

GOLD is of a deep and peculiar yellow colour: it melts at a bright red heat, equivalent, according to Daniell, to 2016° Fahr., and when in fusion, appears of a brilliant greenish colour: its specific gravity is 19·3: it is so malleable, that it may be extended into leaves which do not exceed the $\frac{1}{282000}$th of an inch in thickness, or a single grain may be extended over 56 square inches of surface.

LEAD in colour is blueish white: it has much brilliancy, is remarkably flexible and soft, and leaves a black streak on paper. When handled, it exhales a peculiar odour: it melts at about 612°, and by the united action of heat and air, is readily converted into an oxide. Its specific gravity, when pure, is 11·445; but the lead of commerce seldom exceeds 11·35. Lead is used, in a state of comparative purity, for roofs, cisterns, pipes, vessels for sulphuric acid, &c.

MERCURY is a brilliant white metal, having much of the colour of silver. It has been known from remote ages. It is liquid at common temperatures, solid and malleable at −40° Fahr., and contracts considerably at the moment of congelation: it boils and becomes vapour at about 670°: its specific gravity at 60° is 13·5. In the solid state, its density exceeds 14. The specific gravity of mercurial vapour is 6·976.

NICKEL is a white, brilliant metal, which acts upon the magnetic needle, and is itself capable of becoming a magnet. Its magnetism is more feeble than that of iron,

and vanishes at a heat somewhat below redness. At 6·30° it is ductile and malleable: its specific gravity varies from 8·27 to 8·40 when fused, and after hammering, from 8·69 to 9·00. It is not oxidized by exposure to air at common temperatures; but when heated in the air, it acquires various tints, like steel: at a red heat, it becomes coated by a grey oxide.

Palladium is of a dull white colour, malleable and ductile. Its specific gravity is about 11·3, or 11·86 when laminated. It fuses at a temperature above that required for the fusion of gold.

Platinum is a white metal, extremely difficult of fusion, and unaltered by the joint action of heat and air. It varies in density from 21 to 21·5, according to the degree of mechanical compression it has sustained. It is extremely ductile, but cannot be beaten into such thin leaves as gold and silver.

Rhodium, discovered in 1803 by Dr. Wollaston, is a white metal, very difficult of fusion. Its specific gravity is about 11; it is extremely hard. When pure, the acids do not dissolve it.

Silver is of a more perfect white than any other metal: it has considerable brilliancy, and takes a high polish. Its specific gravity varies between 10·4, which is the density of cast silver, and 10·5 to 10·6, which is the density of rolled or stamped silver. It is so malleable and ductile, that it may be extended into leaves not exceeding a ten-thousandth of an inch in thickness, and drawn into wire much finer than a human hair. Silver melts at a bright red heat, estimated at 1873° Fahr., and when in fusion appears extremely brilliant.

Tin has a silvery white colour, with a slight tint of yellow: it is malleable, though sparingly ductile. Common tin-foil, which is obtained by beating out the metal, is not more than $\frac{1}{1000}$th of an inch in thickness, and what is termed 'white Dutch metal' is in much thinner leaves. Its specific gravity fluctuates from 7·28 to 7·6, the highest being the purest metal. When bent, it occasions a peculiar crackling noise, arising from the destruction of cohesion amongst its particles. When a bar of tin is rapidly bent backwards and forwards several times successively, it becomes so hot that it cannot be held in the hand. When rubbed, it exhales a peculiar odour. It melts at 442°, and by exposure to heat and air is gradually converted into a protoxide.

Zinc is a blueish white metal, with considerable lustre; rather hard; of a specific gravity of about 6·8 in its usual state; but when drawn into wire, or rolled into plates, its density is augmented to 7 or 7·2. In its ordinary state, at common temperatures, it is tough, and with difficulty broken by blows of the hammer: it becomes very brittle when its temperature approaches that of fusion, which is about 773°; but at a temperature a little above 212°, and between that and 300°, it becomes ductile and malleable, and may be rolled into thin leaves, and drawn into moderately fine wire, which, however, possesses but little tenacity. When a mass of zinc which has been fused is slowly cooled, its fracture exhibits a lamellar and prismatic crystalline texture. The pipes of the great organ in the town-hall at Birmingham, and in that of York cathedral, are made principally of sheet zinc.

Meteorology, the term now used for the purpose of designating the science which observes, registers, classifies, and compares the various and varying phenomena of our atmosphere. It remarks, at the same time, the connection of those phenomena with the heavenly bodies, and with the solid and liquid materials of the earth, in reference to

their reciprocal and combined influence in determining the character of different climates, and with the view of learning the meteoric history of every region of our globe, of ultimately investigating the laws of atmospheric change, the plan of meteoric action; the theory, in fact, of meteorological phenomena, on which depend essentially the fitness of the various portions of the earth's surface for the production of distinct vegetable and other substances, and for the support of animal life.

Meteorological phenomena are not confined to the inferior regions of the atmosphere, but extend as far as observations have reached. It is possible their influence may extend universally, and therefore it is desirable to know whether there exists throughout space a medium, or conductor, or whether there is such a thing in matter as vacuum. Some have, it is true, endeavoured to reconcile opinions so diametrically opposed to each other, by suggesting that the universe, though infinite, is a plenum and a void! This (the doctrine of Leucippus) a recent author declares to be really true; and some conceive that the Newtonian theory necessarily implies the reality of a metaphysical void, although the astronomical calculations of that theory were made without any allowance for the resistance to the motions of the planets, which might be experienced from such a medium.

Metoche, the intervals between two denticuli in the Ionic entablature

Metope, the spaces between the triglyphs of the Doric frieze, which in the Parthenon, for instance, were filled in with sculpture; but in modern porticoes that are *said* to be *after the Parthenon*, they are mere blanks

Mètre, a French measure, equal to 39·3702 English inches.

Mezzanine, a low intermediate story between two higher ones

Mezzo-relievo, projection of figures between alto- and basso-relievo; demi-relievo

Mezzotinto, a kind of engraving nearly resembling painting, effected by scraping and burnishing the copper

Mezuzoth, a name given to certain pieces of parchment which were anciently fixed on the door-posts of houses

Mica, an important ingredient in the composition of rocks, consisting of silica, alumina, oxide of iron, and potash: it is easily divided into laminæ, even to the $\frac{1}{500000}$th part of an inch, and is distinguishable from *talc* by its elasticity: in Russia it is used instead of window-glass

Micrometer, an instrument for measuring small spaces

Microscope, an optical instrument for rendering visible minute objects: the *single* microscope has one lens only, and magnifies by permitting a near view of the object; in the *compound* microscope, a focal image is again magnified by other lenses

Middle-ground is a term used, not to express the middle of a picture, but generally perspectively so;—sometimes it is the highest part of a picture, and sometimes the second degree of shade. Pictures are divided into three parts: fore-ground, middle-ground, and back-ground.

Middle-rail, the rail of a door which is upon a level with the hand when hanging freely: the lock of the door is generally fixed in this rail

Midship signifies the middle of a ship

Midship-bend, the broadest frame in the ship, called the 'dead-flat'

Milestones. Pliny says, the miles on the Roman roads were distinguished by a pillar, or a stone, set up at the end of each of them, and which was marked with one or more figures, signifying how far it was from the Milliarium Aureum, a pillar in the forum near the temple of Saturn, which had on it the figure I., so that the next pillar to it, which was marked II., was but one mile from the standard pillar, and consequently

the XIV. and XI. stones were but thirteen and ten miles from the forum.

Illennium, a thousand years; the term applied to that period of the Christian Church described in Revelation, during which, according to many commentators, it is supposed that Jesus Christ will reign personally on the earth, that the bodies of martyrs and other eminent Christians will be raised from the dead, and in this renewed state constitute the subjects of His glorious kingdom

illiare, a Roman mile, consisting of 1000 paces of 5 feet each, and therefore = 5000 feet: taking the Roman foot at 11·6496 English inches, the Roman mile would be 1618 English yards, or 142 yards less than the English statute mile.

Mills for the grinding of grain into flour are of several kinds: windmills, with sails to be impelled by the action of the wind, over-shot and under-shot; and the horizontal, or turbine water-wheels. Mill machinery is used for the grinding of tobacco into snuff, impelled by wind, particularly in Holland, where stupendous structures can be seen on the road from Rotterdam to the Hague. Mills are also used, propelled by steam or water, for the grinding of bark, preparing of flax, sawing of timber, and for the many and varied purposes in manufacture. In the 'Papers on Engineering,' vol. vi., will be found an interesting paper by Mr. Fairbairn on 'Water-Wheels with Ventilated Buckets.'

Millwrights' Planing Machine. This machine is similar in principle to the ordinary planing machine (see *Planing Machine*), except in cases where heavy work is required to be planed, when a machine with a moveable tool and fixed table is used. The advantage of this arrangement is, that very large and heavy castings are planed, which could not be moved to and fro, as in the ordinary machines, without great loss of power. It is placed over a pit made for the purpose, with steps to descend into it. The two side frames are bolted to the ground, and the table has a series of apertures for bolts to fix the work upon it, and can be raised or lowered to any required height by four strong screws, one at each corner. The horizontal and vertical slides are placed over the work in the usual manner, and are attached to a light frame, which, when the tool is adjusted to the work by the vertical slide, is moved to and fro, carrying with it the slides and tool, and at the end of each backward stroke a lappet, or other contrivance, sets the vertical slide and tool a little further across the table, until the entire surface is planed.

Minaret, in Mohammedan architecture, a spire or steeple

Mineral Black is a native and impure oxide of carbon, of a soft texture, found in Devonshire

Mineral Green is the commercial name of green lakes, prepared from the sulphate of copper

Mineralogy forms one of the three great divisions into which natural history or the knowledge of natural objects has been classified; the other two being botany, devoted to plants, and zoology, to animals. Mineralogy is also distinguished from geology, inasmuch as it regards the characters of minerals in detail, without regard to their formation and general distribution in the crust of the earth, which belong to geology. If the composition of a mineral substance is to be considered, then mineralogy forms a portion of chemistry; but in its more limited sense, mineralogy is the art of distinguishing mineral substances from each other, and the science of accurately describing and arranging them, by what may be termed a natural classification.

Mines. Water-springs in mines are

wrongly considered to be of great injury. It is true, the lifting of water by machinery from the deep mines is attended with expense, when they are so situated that no level, drift, or water-course can be obtained for that purpose; but, on the other hand, they are so absolutely necessary in mining, that in the very first process, a judicious miner, in boring down to his mine, previous to his sinking to or working it, even in this simple act, cannot proceed very deep without water to work his bore-rod in; and if the strata of the earth passed through does not produce it, he must pour it down the bore-hole, or he cannot proceed. When all his pits or shafts are sunk, and his mine opened, and ventilation is required to expel inflammable air, fire, or black damp (as it is termed), nothing is superior to water. When this can be obtained, and made to run with facility through the mine and its various workings, it is found superior to air-furnaces of any kind for expelling the fulminating vapours so destructive to the health and lives of the workmen employed.

Mines in Scotland.—The general custom of Scotland provides for yielding to the landlord a royalty proportioned upon the net amount of sales at the colliery, in conjunction with a certain or sleeping rent payable half-yearly. The royalty proportion is sometimes so high as one-quarter the amount of sales, but generally one-eighth; of late years many collieries have been let at one-twelfth and at one-fourteenth the amount of sales.

Mining. There is an essential difference between civil and military mining: in the former, the works are frequently carried on at considerable depths below the surface of the earth, and sometimes in solid rock; whereas military mining is what may be termed superficial, and consequently the miner works through the more recent formations of earths and sands, which, from their little tenacity, he has to support as he advances. For the better ventilation of military mines, a machine has been invented by Sergeant Lewis, of the Royal Sappers and Miners; and it has been conjectured that Mr. Haig's patent pneumatic engine, invented for the purpose of purifying the holds of vessels, might also be successfully employed in mining operations.

Minster, a cathedral, anciently a large church. (See *Westminster Abbey.*)

Minute, a proportionate measure in architecture, by which the parts of the orders are regulated; the sixtieth part of the lower diameter of the shaft of a column, written thus, 10′, *i.e.* ten minutes; in geography and astronomy, the sixtieth part of a degree

Miserere, projecting brackets in the under side of the seats of stalls in churches; they are always more or less ornamented with carvings of leaves and grotesque subjects

Mitre, an episcopal crown. In carpentry, the line formed by the meeting of mouldings or other surfaces which intersect each other. If two pieces of wood be formed to equal angles, or if the two sides of each piece form equal inclinations, and thus be joined together at their common vertex, so as to make an angle double to that of either piece, they are said to be mitred together, and the joint is called 'the mitre.'

Mitre-wheel, a wheel having teeth formed so as to work at an angle of 45° to the centre line of the shaft on which it is fixed, to move with another wheel of equal size, fixed on a shaft at right angles to the former one

Mixed Citrine. There are two principles of combination, of which the artist may avail himself in producing these colours; the one being that of combining two original secondaries, green and orange in pro-

lucing a citrine; the other, the uniting the three primaries in such a manner that yellow may predominate in the case of citrine, and blue and red be subordinate in the compound.

Mixed Grays are formed by the compounding of black and white, which yields neutral grays, and of black and blue, black and purple, black and olive, &c.

Mixed Greens, compounds of blue and yellow pigments, which may be formed by compounding them in the several ways of working, or by blending them in the proportions of the various hues required

Mixed Olive is compounded by uniting green and purple colours, or by adding to blue a smaller proportion of yellow and red, or by breaking much blue with little orange

Mixed Orange. Orange being a colour compounded of red and yellow, the place of original orange pigments may be supplied by a mixture of the two latter colours, by glazing one over the other; by stippling, or other modes of breaking and intermixing them in working, according to the nature of the work and the effect required.

Mixed Purple. Purple being a secondary colour, composed of blue and red, it follows of course that any blue and red pigments which are chemically at variance may be used in producing a mixed purple of any required hue, either by compounding or by grinding them together ready for use, or by combining them in the various modes of operation in painting.

Mixed Russet. Orange, vermillion, and madder purple afford a compound russet pigment of a good and durable colour.

Mizen-mast, in ship-rigging, the mast next the stern

Mock lead, wild lead, black lead, or *black jack*, a ponderous black mineral, which does not readily incorporate in the fire; a zinc ore

Model, a pattern used for moulding; a machine or building executed in miniature

Modillion, a projecting bracket under the corona of the Corinthian and Composite orders, and sometimes of the Roman Ionic

Module, a measure of proportion by which the parts of an order or of a building are regulated in classical architecture; considered generally as the diameter or semi-diameter of the lower end of the shaft of the column; in other words, semi-diameter of the column, or 30 minutes

Molecule, synonymous with *atom*, in physics, a very small mass or portion of any body

Molybdenum, a brittle and white globulous metal

Momentum, in dynamics, is the force of a body in motion. When the motion of a body is considered with respect to the mass, or quantity of matter moved, as well as its velocity, it is called its momentum, or quantity of motion. The momentum of a body is therefore in the compound ratio of its quantity of matter and velocity.

Monastery, an establishment for the accommodation of a religious fraternity, who made it the receptacle of benevolence and charity for the poor and the way-worn. A considerable portion of the land was formerly occupied by the monasteries and other religious houses which existed in Britain, and the endowments of these establishments subsequently became the foundation of the great wealth of some of the early aristocracy in England.

Of the ample means enjoyed by the inmates of these cloistered sanctuaries, some idea may be formed from the following historical statement, translated from the preface to the 'Ely Cartulary,' preserved in the Public Library at Cambridge. After the defeat and death of Harold, many of the leading men of the realm, who had strenuous

opposed the Bastard, fled for refuge to Ely Monastery, together with their friends, "laden with their richest treasures," and withstood, for seven years, the impetuous threatenings of the Normans, until they were unexpectedly surprised. "Then a council being held, it seemed advisable to implore the royal mercy; upon which some were despatched to the king's court, at that time at Warwick, carrying rich treasures to the king, the gift of atonement and compensation of their misconduct; with which the king was satisfied, but on these terms and conditions,—that, during his pleasure, forty royal officers should be lodged at the expense of the monastery. * * The knights are sent for, they arrive, and are present with their household, every one of whom has under him a monk of the first order, as an officer under his earl, or a guest under his host. But the king ordered that the cellarer should dispense provisions to the officers and monks promiscuously in the public hall of the convent. In short, the officers with their earls, the guests with their hosts, the knights with their monks, the monks with their knights, were most grateful to each other; for each and all of them mutually afforded each other the offices of humanity."—After five years passed in this way, the knights were recalled by the Conqueror, to assist in punishing the unnatural wickedness of his son Robert; and "they departed with grief; and our monks, wonderful to relate, lamented the departure of these most illustrious companions, heroic knights, and most pleasing guests, not only in tears, but in dismal howlings and exclamations, and struck their breasts in despair, after the manner of a bride whose husband is unseasonably hurried from her sweet embraces to arms."—All the monks accompanied the knights as far as Hadenham, with hymns, crosses, thuribals, processions, and every solemnity, and, when returned, took care to paint the arms of each knight on the walls of the refectory, to the perpetual remembrance of the uncommon humanity of their military guests."—In the cartulary the names of the knights, forty in number, with their companions, are given; and their arms are emblazoned on the margin.

In addition to the monasteries and nunneries enumerated in the following alphabetical list, no less than 131, which are unnoticed in the Books, are said to have been scattered over England and Wales.

NAME.	ORDER.	DATE.	COUNTY.
Amesbury	Benedictine	980	Wiltshire
Ankerwyke	Benedict. Nuns	1257	Buckinghamshire
Arden	Do.	1150	Yorkshire
Arklow	Benedictine		Wicklow
Armethwaite . . .	Nunnery	Wm. Rufus	Cumberland
Arthington	Do.	1254	Yorkshire
Ashbridge	Augustine	1283	Buckinghamshire
Austin Canons . . .	Do.	1147	Huntingdon
Austin Cell . . .	Do.	1126	Norfolk
Austin Cell . . .	Do.	1256	Norfolk
of Casham on Tweed	Do.	1296	Northumberland
" of Taversham	Do.	1162	Oxfordshire
" *of Halywell* .	Do.	1325	Warwickshire
Austin Nunnery of Legh	Do.	Henry II.	Devonshire
Aylesford	Carmelite	1240	Kent

NAME.	ORDER.	DATE.	COUNTY.
Badlesmere	Augustine	Edward II.	Kent
Barking	Nunnery	630	Essex
Basselech		1101	Monmouthshire
Bearwe	Do.	1200	Somersetshire
Beaulieu	Benedictine	1113	Hertfordshire
Beauvale	Carthusian	1347	Nottinghamshire
Benedictine Cell . .		1349	Cambridge
Birkenhead	Benedictine	1150	Cheshire
Blackborough . . .	Do.	1200	Norfolk
Blakeney	Carmelite	1321	Norfolk
Bleatarn	Cistercian		Westmoreland
Blythebury		Henry I.	Staffordshire
Bretford			Warwickshire
Brewood	Nunnery	1295	Staffordshire
Brewood	Cist. Nunnery	Richard I.	Shropshire
Brodholm	Nunnery	Edward II.	Nottinghamshire
Bromfield	Do.	1115	Shropshire
Bromhale	Do.	1268	Berkshire
Brunham	Nun Priory	1262	Yorkshire
Bungay	Nunnery	1160	Suffolk
Calewich Cell . . .	Augustine	1148	Staffordshire
Calke	Do.	1161	Derbyshire
Canwell		1142	Staffordshire
Canyngton	Nunnery	1140	Somersetshire
Carow	Do.	1146	Norfolk
Castle Hedingham .	Do.	1190	Essex
Catesby	Do.	Richard I.	Northamptonshire
Cell of Lees . . .			Staffordshire
Charter-house . . .	Carthusian	1348	London
Chateris	Nunnery	980	Cambridgeshire
Cheshunt	Do.	1183	Hertfordshire
Chester	Do.	1264	Cheshire
Clerkenwell . . .	Do.	1100	Middlesex
Clonard	August. Nun.	1195	Meath
Clynnock Vaux . .	Cistercian	616	Carnarvonshire
Codenham	Nunnery	Henry II.	Yorkshire
Cokehill	Cist. Nunnery	1260	Worcestershire
Cokwelle	Do.	1185	Lincolnshire
Coln		1100	Essex
Cornworthy . . .	Nunnery	1461	Devonshire
Crabhouse	August. Nun.	1181	Norfolk
Dartford	Nunnery	1355	Kent
Davington	Benedict. Nun.	1153	Kent
Derby	Nunnery	1160	Derbyshire
Dodford	Cell Premonst.	1184	Worcestershire
Dunster	Benedictine	Wm. Conq.	Somersetshire
Durham College . .	Ed$^{m.}$ of Monks	1285	Oxford
East Dereham . .		650	Norfolk
Ellerton	Cist. Nunnery	Edward I.	Yorkshire
Elstow	Nunnery	1078	Bedfordshire
Fairwell	Benedictine	1140	Staffordshire
Farne Island . . .	*Do.*	651	Northumberland
Felixtow	*Do.*	Wm. Rufus	Suffolk

NAME.	ORDER.	DATE.	COUNTY.
Flamstead	Benedict. Nun.	1220	Hertfordshire
Floxton	Nunnery	1258	Suffolk
Folkestone		630	Kent
Fosse	Cist. Nunnery	Henry III.	Lincolnshire
Gloucester College, or Hall . . .	Benedictine	1260	Oxford
Godeland		King John	Yorkshire
Godestow	Nunnery	1138	Oxfordshire
Goring	Do.	Henry II.	Oxfordshire
Grany	Benedict. Nun.	1200	Kildare
Greisley	Augustine	Henry I.	Derbyshire
Grimesby	Benedictine	1185	Lincolnshire
Haliwell	Nunnery	1127	Middlesex
Handale		1133	Yorkshire
Henwood	Do.	1228	Warwickshire
Heyninges	Cist. Nunnery	1180	Lincolnshire
Hinchingbrook . .	Nunnery	Wm. Conq.	Huntingdonshire
Hode	Cell	1138	Yorkshire
Holystan	Nunnery	1255	Northumberland-
Horewelle	Cistercian	1291	Warwickshire
Horne		1226	Suffolk
Ikelington	Nunnery	1140	Cambridgeshire
Ilchester Hospital . .	Do.	1217	Somersetshire
Inch Colme . . .	Augustine	1133	Fifeshire
Ivingho	Nunnery	1160	Buckinghamshire
Jarrow	Benedictine	684	Durham
Kaylend	Premonstrant		Northamptonshire
Kells and Inistioge .	Augustine	1183	Kilkenny
Kilburn	Nunnery	1191	Middlesex
Kirklees	Cist. Nunnery	1291	Yorkshire
Lacock	Nunnery	1232	Wiltshire
Lakeburn	Cist. Nunnery	1150	Lincolnshire
Lambly upon the Tyne	Nunnery	1292	Northumberland
Lammana	Benedictine	1200	Cornwall
Langley	Nunnery	King Canute	Leicestershire
Lestingeham . . .		648	Yorkshire
Letteringham . . .	Augustine		Suffolk
Liming		633	Kent
Lindisfarne		1082	Northumberland
Littlechurch . . .	Nunnery	1151	Kent
Little Marcis . . .	Benedict. Nun.	1163	Yorkshire
Little Marlow . . .	Nunnery	1230	Buckinghamshire
Littlemore	Benedict. Nun.	1177	Oxfordshire
Llanlorgan	Cist. Nunnery	1239	Montgomeryshire
Lymbroke		1036	Herefordshire
Malling	Nunnery	945	Kent
Malpas	Cluniac	Henry I.	Monmouthshire
Marham	Cistercian Nun.	1249	Norfolk
Marrick	Nunnery	1171	Yorkshire
Marton	Augustine	temp. Steph.	Yorkshire
Mergate	Benedictine	1145	Bedfordshire
Middleburgh . . .	Benedictine	1120	Yorkshire
Middleton	Do.	933	Dorsetshire

NAME.	ORDER.	DATE.	COUNTY.
Iolesby	Nunnery	1167	Yorkshire
Ionkton		1268	Yorkshire
Ieddrum	Benedictine	1177	Devon
Iewcastle	Black Friars	1260	Northumberland
Iun-Appleton . . .	Cistercian	K. Stephen	Yorkshire
Iun-Cotun	Do.		Lincolnshire
Iun-Kelynge . . .	Nunnery	1152	Yorkshire
Oxney			Northamptonshire
Peykirk		714	Northamptonshire
Pinley	Benedictine	1195	Warwickshire
Pinwortham . . .	Do.	Wm. Conq.	Lancashire
Polslo	Nunnery	1169	Devonshire
Reculver		669	Kent
Redburne	Nunnery	1178	Hertfordshire
Redlingfield	Do.	1120	Suffolk
Reinton, St. Michael .	Do.	1274	Wiltshire
Rosedale	Do.	1310	Yorkshire
Rothwell	August. Nun.	1305	Northamptonshire
Rowney	Nunnery	1164	Hertfordshire
Rumsey	Benedictine	967	Hampshire
Rusper	Nunnery	1291	Sussex
Scarthe	Augustine	Henry I.	Yorkshire
Scilly, in the Isle of Trescaw		1346	Cornwall
Selsey		711	Sussex
Seton	Benedict. Nun.	1227	Cumberland
Sewardesley . . .	Cisterc. Nun.	Henry II.	Northamptonshire
Shepey	Nunnery	675	Kent
Sinningthwaite . . .	Cistercian	1160	Yorkshire
Snelleshall	Black Monks	1219	Buckinghamshire
Sopwell	Nunnery	1140	Hertfordshire
Stanfeld	Do.	1278	Lincolnshire
Stanford	Benedict. Nun.	1156	Northamptonshire
St. Anne	Carthusian	1381	Warwickshire
St. Bartholomew . .	Nunnery	1086	Northumberland
St. Bernard's College.	Cistercian	1437	Oxford
St. Clement . . .	Nunnery	1130	Yorkshire
St. Dogmael . . .		Wm. Conq.	Pembrokeshire
St. Edmund's Bury .		633	Suffolk
St. German's . . .	Benedictine	614	Cornwall
St. Helen	Nunnery	1212	London
St. Ive (Cell of) . .	Benedictine	1001	Huntingdonshire
St. John Baptist . .	Do.	Edward I.	Cork
St. Martin's	Do.	1100	Yorkshire
St. Mary de Pré . .	Do.	1190	Hertfordshire
St. Mary Magdalen .		1170	Bristol
St. Mildred's . . .	Nunnery	670	Kent
St. Nicholas . . .	Benedictine	1103	Exeter
St. Rategund . . .	Benedict. Nun.	1130	Cambridgeshire
St. Sepulchre's . .	Nunnery	1100	Canterbury
St. Syriae	Cluniac	Richard I.	Cornwall
Stodely	Nunnery	1184	Oxfordshire
Stratford at Bow . .	Benedictine	Wm. Conq.	Middlesex

NAME.	ORDER.	DATE.	COUNTY.
Stykoswold	Cisterc. Nun.	K. Stephen	Lincolnshire
Swaffham	Nunnery	1255	Cambridgeshire
Syon	Do.	1414	Middlesex
Tarent	Cisterc. Nun.	Richard I.	Dorsetshire
Thicked	Nunnery	1214	Yorkshire
Trentham	Augustine	Henry I.	Staffordshire
Wallingwell	August. Nun.	K. Henry	Northamptonshire
Wherwell	Nunnery	986	Hampshire
Whiston	Cisterc. Nun.	1255	Worcestershire
Wilberfosse	Nunnery	1153	Yorkshire
Wilton	Benedictine	773	Wiltshire
Winchester	Nunnery	900	Hampshire
Winteneye	Cisterc. Nun.	1200	Hampshire
Wroxhall	Benedictine	Wm. Conq.	Warwickshire
Wyckham	Cisterc. Nun.	1153	Yorkshire
Wykes	Do.	Henry II.	Essex
Wyrthorp	Nunnery	1357	Northamptonshire
Yarmouth	Benedictine	1101	Norfolk

Monkey-wrench, a spanner with a moveable jaw, which can be adjusted by a screw or wedge to the size of the nut which it is required to turn

Monogram, a cipher composed of two or more letters interwoven as an abbreviation of a name: monograms were common as distinctive marks on ancient coins, and were also used as seals

Monolithic, consisting of a single stone: statues, columns, and pillars were formed by the ancients out of large blocks of stone or marble

Monopteral, a temple which has no cella, but consists of columns disposed in the form of a circle, covered with a conical roof

Monota, a vase with one handle

Monotriglyph, the interval observed between the columns of a Doric portico, where a space is left sufficient for the insertion of one triglyph only between those immediately over two contiguous columns

Monstrance, sometimes called *Remonstrance*, the vessel in which the consecrated wafer or host is placed while the congregation are blessed with it, in the Roman Catholic Church. In the 'Divers Works of Early Masters,' 2 vols. folio, will be found two of the rarest and most elaborate examples of tabernacles or canopies, in a compartment of either of which the casket or vessel containing the sacred vessel is deposited.

Monton, a heap of ore; a batch under process of amalgamation, varying in different mining districts

Monument, a mausoleum or tomb. Sepulchral monuments of the middle ages still exist to a considerable extent, both here and on the Continent. Monuments and tombs of modern date are designed from Classical and Gothic architecture, and in many instances are beautiful models of modern art.

Moor, in Cornish, a root, or quantity of ore in a particular part of a lode, as a 'moor of ore,' a 'moor of tin'

Moorish, Mohammedan, or *Saracenic Architecture*, is a combination of Egyptian, Grecian, and Roman details; first established by the Arabs about the tenth century, and for oriental scenery of a pleasing character: its complicated ornament and lattice-work are rich and peculiar. Many existing examples are interesting; but the style is wholly unfit for European usages and requirements.

Moot-hall, or *Moot-house*, in Saxon times, a building appropriated to

assemblies on public affairs; a *guild-hall* or *town-hall; hôtel de ville*, &c.

Mora wood. This tree is 100 feet high, and abundant; it is close-grained, like teak, and superior to oak; esteemed for ship-building.

Moresque, a kind of painting, carving, &c., in the arabesque and grotesque styles of ornament

Mortar. The materials which are added to lime, in the formation of mortars or calcareous cements, are, 1st, The different kinds of sand, properly so called; 2nd, arenes; 3rd, psammites; 4th, clays; 5th, volcanic or pseudo-volcanic products; and 6th, artificial products arising from the calcination of the clays, the arenes, and the psammites; and the rubbish and slag of manufactories, forges, &c.

INGREDIENTS OF MORTAR.

SAND.—The granitic, schistose, and calcareous rocks, free-stones, &c., reduced to the state of hard and palpable grains, either by the agitation of water, or by spontaneous disaggregation, give birth to the various kinds of sand. We distinguish them from powders by their falling at once to the bottom, when thrown into limpid water, and that without altering its transparency in a sensible degree.

The disaggregation of rocks is often accompanied by a decomposition which produces a powder: this powder renders the sand 'rich,' or, in other terms, susceptible of a certain cohesion, when tempered with water. Washed by rains and currents of water, it is soon freed from the pulverulent particles, and is deposited pure in the beds of rivers. This purity is often changed near the mouths of streams, and in the small rivulets whose tributaries flow over a bed of clay or mould: the sand mixes with vegetable débris and animal matters, and becomes 'loamy.' The particles composing sand faithfully represent those of the rocks whence they are derived. The granitic regions furnish quartz, felspar, and mica; and the volcanic regions, lavas of all kinds. The tabular-shaped sands, whose particles are tender, are furnished by the schistose mountains. It is difficult for them to be transported far without being reduced to powder.

The calcareous sands are the least common, probably arising from the fact that rivers generally take their rise from primitive summits, or such as are composed of primitive elements. The calcareous rocks, besides, are not susceptible of that kind of disaggregation which can be called granitic; for if they be of a soft kind, they produce powder; if hard, scaly splinters.

The partial and secondary revolutions of the globe have occasioned immense deposits of sand in situations where now neither brooks nor rivers flow: these are the fossil sands; and they should be carefully distinguished from the virgin sands, which are still in their original site, and have not been operated on by the waters.

The fossil sands generally exhibit a more angular grain than the sea or river sands; but in other respects they are the same elements, sometimes pure, sometimes coloured by ochres, &c.

Among the fossil sands is one very remarkable, the arene. Its properties entitle it to attention.

ARENES is a sand, generally quartzose, with very irregular, unequal grains, and mingled with yellow, red, brown, and sometimes white clay, in proportions varying from one to three-fourths of the whole volume.

The arene almost always occupies the summits of the rounded and moderately-elevated hills: it sometimes constitutes entire hillocks; frequently it interposes itself in large veins and seams in the clefts of calcareous rocks: it belongs essentially to alluvial soils.

Psammites is a term applied to an assemblage of the grains of quartz, schist, felspar, and particles of mica, agglutinated by a variable cement. The varieties of these are very numerous: those which in appearance strongly resemble the free-stones and silicious breccias belong to the class of rocks whose disaggregation furnishes sand, properly so called. But the psammites, which are slaty, of a yellow, red, or brown colour, fine-grained, unctuous to the touch, producing a clayey paste with water, form a distinct species, and one which merits attention.

These last belong to the primitive schistose formations: they do not and cannot exist except *in situ:* they are found in beds or veins, forming part of the schist of which they are merely a decomposition.

Clays are earthy substances variously coloured, fine, soft to the touch, which diffuse in water with facility, forming with it a paste, which, when kneaded to a certain consistency, possesses unctuosity and tenacity, and may be drawn out and kneaded in every direction without separating. The clayey paste, when dried, retains its solidity, hardens in the fire, &c.

Clays are essentially composed of silica and alumina: these two substances are adulterated by the presence of the oxide of iron, the carbonates of lime and magnesia, sulphuret of iron, and of vegetable combustible matter partly decomposed.

The clays are separated into four classes: viz. the refractory, which resist, without melting, the heat of the porcelain furnaces (140° Wedgwood); the fusible clays; the effervescing or clayey marls; and, lastly, the ochrey clays, coloured red or pure yellow by oxide of iron.

The position of clays is very varied: *they are found* as veins in primitive formations; in hillocks, on *the confines of the* primitive chains; in horizontal beds, or layers, in the secondary formations; in threads, thin veins, or infiltrations, in chinks and hollows of calcareous masses; lastly, in volcanic regions, where their formation is attributed to the decomposition of the compact lavas, and perhaps also, with some probability, to miry eruptions.

Mortar. Considered as a plastic material, mortar fit for moulding may be made to take every possible form in moulds or shapes. To give it the appearance of stone, it should be made with fine colourless sand, or rather with fine calcareous powders derived from hard stones.

Mortar contained in a mould may be beaten or rammed in the manner of pisé,—"a mode of building formerly in use, whereby walls were formed by ramming and beating down earth, clay, &c., between upright planks,"—and acquires by that means great compactness; but an increase of resistance does not always result from this.

In order that any material be beaten with effect, it is necessary that it should possess a certain degree of consistency, which is a mean between complete pulverulence and that state of ductility which constitutes a firm paste. No compression is possible when the material escapes from under the rammer; and this is still practised by the builders in pisé, who never employ any but earth slightly moistened. Mortar may always be prepared in this way, leaving it, after it has been worked in the ordinary manner, to undergo desiccation to a proper extent.

The successive approximation of the particles of the compressed material to one another necessarily determines a foliated structure, which, though it may not be perceived, is nevertheless real. Analogy will lead to the conclusion, that, in every possible case, a body thus formed ought to oppose a

greater resistance to a tractile force in proportion as its direction forms a smaller angle with the plane of the laminæ; however, experience shows that this in general does not take place. The following has been determined in this respect:

1st, Beating has the effect of augmenting the absolute resistance of mortars of rich limes and pure sand in every case, but in an unequal manner. The greatest resistance assumes a direction perpendicular to the planes of the laminæ when the mortars are buried in a damp soil immediately after their fabrication. It remains parallel to these same planes when the mortars have been exposed to the atmospheric influence.

2nd, The effect of beating is not constantly useful to mortars of hydraulic or eminently hydraulic limes, and calcareous or quartzose sands or powders, except in the case when these mortars are used under a damp soil. The greatest resistance is then in a direction perpendicular to the planes of these laminæ, as with the mortars of rich limes; but in the air, the superiority of the mortars which have been beaten over those which have not is only exhibited in one direction, and that is parallel to the plane of the laminæ.

3rd, Beating becomes injurious in every case when the hydrates of the hydraulic or eminently hydraulic limes are employed without admixture, and subjected to the influence of a damp soil; and is favourable to it only in the direction parallel to the laminæ when the stuff dries in the air.

Considered as a plastic substance, the numerous casts which have been moulded, both in bas-relief and alto-relievo, prove that mortar receives and retains impressions well: their hardness is continually on the increase, and a kind of varnish, with which time covers them, gives them a strong resemblance to stone.

One problem remains to be solved, viz. to discover a means of hastening the set of mortar without injuring its future qualities; and this, in order to avoid being obliged to multiply moulds indefinitely for the same casting. This last desideratum appears to be difficult. The natural cements, which harden almost instantly in the air and in the water, when worked up like plaster of Paris, are subject to the inconvenience of being tinged brown. Such as are fabricated artificially, by calcining mixtures of lime and clay free from iron, do not stand the weather.

Mortar of hydraulic lime may be employed as a plastic substance in a multitude of cases, in which the number of moulds is no inconvenience. Such is the case in the preparation of artificial stones bearing mouldings, vases, or ornaments of any kind susceptible of formation by the rectilinear or circular movement of a profile. It is evident that it will then answer to set the mould in a trench, and run the profile along the clayey paste, prepared and arranged for that purpose. The economy which such a process would introduce into ornamental constructions is indeed incredible.

Mortise, in carpentry, a hole cut in a piece of wood, to receive a corresponding projection formed upon another piece

Mortise and Tenon. The following rules may be referred to as *data* for the workman in ordinary practice.

The tenon, in general, may be taken at about one-third of the thickness of the wood.

When the mortise and tenon are to lie horizontally, as the juncture will thus be unsupported, the tenon should not be more than one-fifth of the thickness of the stuff, in order that the strain on the upper surface of the tenoned piece may not split off the under-cheek of the mortise.

When the piece that is tenoned is not to pass the end of the mortised piece, the tenon should be reduced one-third or one-fourth of its breadth, to prevent the necessity of opening one side of the tenon. As there is always some danger of splitting the end of the piece in which the mortise is made, the end beyond the mortise should, as often as possible, be made considerably longer than it is intended to remain; so that the tenon may be driven tightly in, and the superfluous wood cut off afterwards.

But the above regulations may be varied, according as the tenoned or mortised piece is weaker or stronger.

The labour of making deep mortises, in hard wood, may be lessened, by first boring a number of holes with the auger in the part to be mortised, as the compartments between may then more easily be cut away by the chisel.

Before employing the saw to cut the shoulder of a tenon in neat work, if the line of its entrance be correctly determined by nicking the place with a paring chisel, there will be no danger of the wood being torn at the edges by the saw.

As the neatness and durability of a juncture depend entirely on the sides of the mortise coming exactly in contact with the sides of the tenon, and as this is not easily performed when a mortise is to pass entirely through a piece of stuff, the space allotted for it should be first correctly gauged on both sides. One half is then to be cut from one side, and the other half from the opposite side; and as any irregularities which may arise from an error in the direction of the chisel will thus be confined to the middle of the mortise, they will be of very little hindrance to the exact *fitting of the sides* of the mortise *and tenon. Moreover,* as the tenon *is expanded* by wedges after it is *driven in, the sides* of the mortise may, in a small degree, be inclined towards each other, near the shoulders of the tenon.

M-roof, a roof formed by the junction of two common roofs with a vallum between them

Mosaic-work, the art of picturing with small pebbles and shells of various colours, pieces of glass, marble, &c. cemented on a ground of stucco

Mosque, a Mohammedan temple

Motif, that which suggests a hint or idea to an artist; also the hint itself

Motion. The cross-head, cross-head guides, and blocks, in a locomotive engine, taken as a whole, are called 'the motion.'

Motion (*laws of*). A body must continue for ever in a state of rest, or in a state of uniform and rectilineal motion, if it be not disturbed by the action of some external cause. The alteration of motion produced in a body by the action of any external force is always proportional to that force, and in the direction of the right line in which it acts. The action and reaction of bodies on one another are equal, and are exerted in opposite directions.

Motion of bodies on inclined planes. The force of an inclined plane bears the same proportion to the force of gravity as the height of the plane bears to its length; that is, the force which accelerates the motion of a body down an inclined plane, is that fractional part of the force of gravity which is represented by the height of the plane divided by its length.

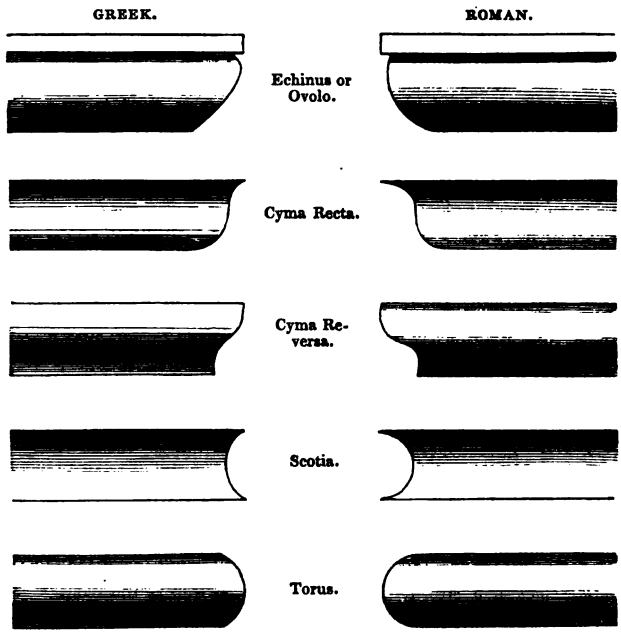
Mould, the model or pattern used by workmen as a guide in working mouldings and ornaments, in the casting of metal, and models of machinery

Mouldings, a term applied to all the varieties of outline or contour given to the angles of the various subordinate parts and features of buildings, whether projections or cavities, such as cornices, capitals, bases, door or window jambs, and

heads, &c. There are eight sorts of regular mouldings, viz. the Ovolo, the Talon, the Cyma, the Cavetto, the Torus, the Astragal, the Scotia, and the Fillet. These mouldings are not to be used at hazard, each having certain situations adapted to its reception, to which it must always be applied. Thus the ovolo and talon, from their peculiar form, seem intended to support other important mouldings or members; the cyma and cavetto being of weaker contour, should only be used for the cover or shelter of other parts; the torus and astragal, bearing a resemblance to a rope, appear calculated to bind and fortify the parts to which they are applied; the use of the fillet and scotia is to separate one moulding from another, and to give a variety to the general profile. The ovolo and talon are mostly placed in situations above the level of the eye; when below it, they should only be applied as crowning members. The place for the scotia is universally below the level of the eye. When the fillet is very wide, and used under the cyma of a cornice, it is termed a corona; if under a corona, it is called a band.

The curved contours of mouldings are portions of either circles or ellipses.

The principal mouldings, and the difference of their profiles in the Grecian and Roman styles, are here exhibited.



Moulding, the process of forming a *cavity in sand or loam*, in order to *give its form to metal* which is applied in a fluid state; an ornamental cavity in wood, stone, or other suitable material

Mountain-blue. A very beautiful substance of this kind, a carbonate of copper, both blue and green, is found in Cumberland. None of these blues of copper are, however, durable; used in oil, they become green, and, as pigments, are precisely of the character of verditers.

Mountain-green is a native carbonate of copper, combined with a white earth, and often striated with veins of mountain-blue, to which it bears the same relation that green verditer does to blue verditer; nor does it differ from these and other copper-greens in any property essential to the painter

M. S., an abbreviation commonly used on tomb-stones or monumental tablets, for the Latin words *Memoriæ Sacrum*, 'Sacred to the Memory': the letters *J. H. S.* are often similarly applied in sacred edifices, for *Jesus Hominum Salvator*, — 'Jesus the Saviour of Men.'

Mud-holes, the covered openings in the bottom of a boiler for discharging the dirt and sediment

Mud-plugs, in locomotive engines, tapered screw-plugs fitted into convenient parts of the boiler, to admit of its being washed out by these plug-holes when necessary

Mulberry-tree, a wood of great variety, principally from Rio Janeiro, and very suitable for furniture

Mullion, the division between the lights of windows, screens, &c. in Gothic architecture: the styles or upright divisions in wainscoting are also sometimes called mullions

Mule-jenny, a machine used in the manufacture of cotton thread

Mun (Cornish), any fusible metal

Mundick, an exceedingly ponderous mineral, whitish, beautiful and shining, but brittle. It is abundant in Cornish and Irish mines.

Muniment-house, a strong, properly fire-proof apartment in public or private buildings, for the preservation of charters, deeds, seals, &c.

Munnions, pieces that part the lights *in a ship's stern* and quarter-gallery

Munnions, in house-building, upright posts that divide the lights in a window-frame

Mummy, or *Egyptian-brown*, is a bituminous substance, combined with animal remains, brought from the catacombs of Egypt, where liquid bitumen was employed three thousand years ago in embalming, in which office it has been combined, by a slow chemical change, during so many ages, with substances which give it a more solid and lasting texture than simple asphaltum; but in this respect it varies exceedingly

Mural, pertaining to a wall; a monumental tablet affixed to a wall is a mural monument

Murometer, an instrument to measure small spaces

Murus, the wall of a Greek city, in contradistinction to Paries, the wall of a house, and Maceria, a boundary wall

Music. This word is derived from the Latin *musica*, and this again from the Greek adjective *mousikos*, which signifies, of or belonging to the Muses. As a substantive, the word *mousikos*, or in Latin *musicus*, a musician, means also a poet or an orator; and in the feminine gender signifies the liberal arts, but especially music, poetry, and eloquence. The ancients, therefore, understood by music far more than has been attributed to it for some ages past. Music is now considered as the language of agreeable sounds, and is both a science and an art. As a science, it teaches the theory of musical sounds, their production by the vibrations of the air, the ratio of these vibrations, and also their times; likewise the various phenomena connected with musical sounds, the causes of discords, beats, &c., as well as the lengths of musical strings and pipes. The mathematical theory of music is part of the science of acoustics, or phonics, and is therefore one of the high mechanical sciences. As an

art, music teaches the practical use of the science; the scales or gamuts of sounds in a fixed succession, at fixed intervals from each other; the permutations of their sounds; forming an immense variety of melodies. It teaches also the combination of these sounds according to certain received laws, forming thereby the most agreeable sensations on the ear, by producing a great variety of chords, composed of concordant sounds alone, or of a judicious admixture of concordant and dissonal sounds. Practical music teaches also the use and performance of the several instruments of music, as also their peculiar functions; and herein is embraced the human voice, the most perfect and beautiful of all musical instruments. Music, therefore, is divided into two grand parts, viz. theoretical or scientific, and practical; the former treating of the purely philosophical branch mathematically, the latter being confined solely to the production of musical compositions, and their performance. Practical music consists of several species, the highest of which is the ecclesiastical; then follow the oratorio, opera, military, chamber, and ball-room species; and is divided into vocal and instrumental music, each of these being variously subdivided.

Musnud, in Persia, a throne or chair of state

Mustaib, a wood from the Brazils, inferior to rose wood, but harder; used at Sheffield for the handles of glaziers' and other knives, &c.

Mutule, a projecting block worked under the corona of the Doric cornice, in the same situation as the modillions in the Corinthian and Composite orders; it is often made to slope downward towards the most prominent part, and has usually a number of small guttæ or drops, worked on the under side

Mynchery, the Saxon name for a nunnery: nuns were sometimes called Mynchies

Myoparo, a small piratical craft, employed by the Saxon corsairs

Myriad, the number of 10,000; proverbially any great number

Myriamètre, a French measure of 10,000 mètres

NAI

NAILS, used in building, are small metallic spikes serving to bind or fasten the parts together. There are several kinds of nails, called by numerous names. In the middle ages, nails were frequently used much ornamented, of which there are several very beautiful existing specimens, particularly in church doors and the gates of large mansions.

Naked, of a column or pilaster, the surface of the shaft where the mouldings are supposed to project

Naked, of a wall, the remote face whence the projectures take their rise. It is generally a plain surface, and when the plan is circular, the naked *is the surface of a cylinder, with its axis perpendicular to the horizon.*

NAP

Naked flooring, in carpentry, the whole assemblage or contignation of timber-work for supporting the boarding of a floor on which to walk. Naked flooring consists of a row of parallel joists, called floor-joists.

Naos, the chamber or enclosed apartment of a Greek temple. The part of the temple which stood before the naos, comprehended between the wall and the columns of the portico, was called the pronaos; while the corresponding part behind was called the *posticum*.

Naples yellow is a compound of the oxides of lead and antimony, anciently prepared at Naples under the name of Grallolina; it is supposed also to have been a native production of Vesuvius and othe

volcanoes, and is a pigment of deservedly considerable reputation. It is not so vivid a colour as patent yellow and turbith mineral, but is variously of a pleasing light, warm, golden-yellow tint. Like most other yellows, it is opaque, and in this sense is of good body. It is not changed by the light of the sun, and may be used safely in oil or varnish, under the same management as the whites of lead; but like these latter pigments also, it is liable to change even to blackness by damp and impure air when used as a water-colour, or unprotected by oil or varnish.

Naphtha, a species of mineral oil or fluid bitumen, now commonly used for lamps

Narthex, a division in the early Christian churches in which the catechisms were said, and penitents admitted; it was near the entrance, and separated from the rest of the church by a railing or screen

Nasmyth's patent direct-action steam-hammer is employed instead of the old helves or lift-hammers, and is worked by a connected high-pressure steam engine, which raises the hammer to any required height within its vertical range of motion, and in which it is guided by two planed guides. On the escape of the steam, when the valve of the cylinder is opened, the hammer falls on the work that lies on the anvil with the full force due to gravity, without scarcely any loss from friction. The instant the hammer has given its blow, the steam is again let in under the piston, and the same action is repeated with ease and rapidity.

Nasmyth's steam pile-driving engine. There are two grand or important features of novelty in this pile-driving engine, compared with all former contrivances for the like purpose. In the first place, by the employment of the steam-hammer action, the steam is made to act direct in raising up and letting fall the hammer, or monkey, without the intervention of any rotatory motion; while, in the second place, another grand feature consists in the employment of the pile about to be driven, or raised up and planted in its situation by the machine, by means of a windlass worked by a small detached steam engine.

Some conception of the rapidity with which piles are driven by this machine may be formed, when it is stated that a pile measuring 60 feet in length, and 14 inches square, can be driven 45 feet into stiff soil, down to the rock below, in four minutes; and such is the good effect resulting from the blows by being given by a great mass of 30 cwt. striking quickly, but with small velocity of actual impact, that the head of the pile requires no hoop, and presents, after being driven, a neater appearance than it had when it was first placed under the hammer.

Natural beds of stone are the surfaces from which the laminæ are separated. It is all important for the duration of stone walls, that the laminæ should be placed perpendicular to the face of the work, and parallel to the horizon.

Natural Philosophy takes an extensive range, embracing the study of the collection of created beings and objects, and of those laws by which they are governed, all of them expressed in the term Nature. Natural objects are separated into two grand classes, the organic and inorganic; the former being distinguished by vital power or life: organic bodies admit of a marked distinction into animals and plants; the science of Zoology describing and classifying the one, and that of Botany the other. These sciences admit of many subdivisions, and collectively with Mineralogy, that of Natural History:

1. Geology, the science which has

for its object the observation and description of the structure of the external crust of the globe; Mineralogy taking account only of the separate items of which the earth's crust is composed. 2. Chemistry, which may be regarded as atomic anatomy, its object being to decompose bodies, to study the properties of their elements, and the laws of combination. 3. Physics, or Natural Philosophy, which considers the general properties of all bodies. Natural philosophy is again subdivided into many distinct sciences. The mutual action of forces and masses of matter produces in the latter either equilibrium or motion, and hence arise those two divisions of sciences, called Statics and Dynamics, which are again divided into Stereo-statics and Stereodynamics, as applied to solids; Hydrostatics and Hydrodynamics, as applied to liquids; Electro-statics and Electro-dynamics, as applied to Electricity. The application of statics and dynamics to air and other gaseous fluids is called Pneumatics. The application of dynamics to the arts of life has led to the composition and arrangement of the various machines for assisting the labour of man: this branch is called Mechanics. The construction and performance of the various machines to raise water, or which are driven by the motion of that fluid, belong to hydronamics, while the construction of works depending on the equilibrium of liquids belongs to hydrostatics. Those machines which are driven by the wind depend on the application of pneumatics; and all the varied phenomena of the atmosphere arising from the action of heat, light, electricity, and moisture, form the science of Meteorology. The phenomena of heat and electricity also form separate sciences; *the latter admitting of five divisions, viz. electricity, magnetism, galvanism or voltaic electricity, thermo-*electricity, and animal electricity. The phenomena of light, although included in the term Optics, are varied; namely, perspective, catoptrics, dioptrics, chromatics, physical optics, and polarization; to which may be added actino-chemistry.

Naumachia, among the Greeks, a sea-fight; a spectacle. The term was also applied to a circus encompassed with seats and porticoes, the pit of which, serving as an arena, was filled with water by means of pipes, for the exhibition of sea-fights.

Naupegus, a shipwright

Nautical, pertaining to ships or sailors

Naval Architecture, the art of designing and constructing ships and vessels for the purposes of navigation

Navale, a ship-dock or dockyard

Navalia, ship-building docks at Rome, where also ships were laid up and refitted

Navarchus, among the ancients, the name of a commander or admiral of a fleet

Nave, the body of a church west of the choir, in which the general congregation assemble. In large buildings it consists of a central division, with two or more aisles; and there are frequently, in foreign structures, several small chapels on the sides beyond the aisles. In mechanics, the central part of a wheel.

Navel-hoods, in ship-building, pieces of plank, or thick stuff, wrought above and below the hawse-holes

Navis, in church furniture, a metal dish or vessel to contain frankincense

Neap, low, decrescent; a term applied to the tides which happen when the moon is in the middle of her second and fourth quarters. The highest spring-tide is three days after the full or change; the lowest neap-tide is four days before the full or change.

Nebule moulding, an heraldic term. In architecture, an ornament of th

zigzag form, but without angles: it is chiefly found in the remains of Saxon architecture, in the archivolts of doors and windows.

Neck of a capital, the space between the channelures and the annulets of the Grecian Doric capital. In the Roman Doric it is the space between the astragal and the annulet.

Neck-mould, in architecture, a small convex moulding surrounding a column at the junction of the shaft and capital

Necrology, an obituary formerly kept in churches and monasteries

Needle, or *Nail*, in mining, a long taper piece of copper or iron, with a copper point; used when stamping the hole for blasting, to make by its insertion an aperture for a fusee or train

Needle-work, a term anciently used for the frame-work of timber and plaster in old houses

Neo, a Greek term, to spin or twist a number of separate fibres of wool or flax into a single thread

Ne plus ultra (Latin), the extreme of any thing

Nervures, nerves or *branches*, a term applied by Prof. Willis, of Cambridge, to the ribs of a vaulted roof which bound the sides of any groined compartment

Net, or *Neat*, in commerce, that which is pure and unadulterated; the weight of any package after the *tare* has been deducted: most commonly, but improperly, written *nett*

Newel, the central column round which the steps of a circular staircase wind; the principal post at the angles and foot of a staircase. In the Tudor and Elizabethan residences very beautiful examples exist, adding much to the beauty of the staircase.

Niche, in architecture, a cavity or hollow place in the thickness of a wall, in which to place a figure, a statue, vase, or ornament. Niches are made to partake of all the segments under a semicircle: they are sometimes at an equal distance from the front, and parallel or square on the back with the front line, in which case they are called square recesses, or square niches. Occasionally small pediments were formed over them, supported on consoles, or small columns or pilasters placed at the sides of the niches. Anciently they were used in ecclesiastical buildings for statues and shallow square recesses. The ruins of Palmyra exhibit niches of various kinds. Within the portico of the temple of the Sun there are two niches, &c.

Niche, angular, one formed in the corner of a building

Niche, in carpentry, the wood-work to be lathed-over for plastering. The usual constructions of niches in carpentry are those with cylindrical backs and spherical heads, called cylindro-spheric niches, the execution of which depends upon the principles of spheric sections.

Niche, ground, that which, instead of bearing on a massive base or dado, has its rise from the ground,—as the niches of the portico of the Pantheon at Rome: their ordinary proportion is, two diameters in height, and one in width. Round or square niches are also formed.

Nigged ashlar, stone hewn with a pick or pointed hammer, instead of a chisel; used principally at Aberdeen for the hewing of the hard granite

Nitrate of lime, nitric acid in combination with lime for a base, abounding in the mortar of old buildings

Nitrates, compounds, or salts, formed by the combination of nitric acid with alkalies, earths, and metallic oxides

Nitre, common saltpetre; in chemistry, nitrate of potash

Nodus, anciently, in our cathedrals, a knot, key-stone, or boss

Nog, in ship-building, a treenail driven through the heel of the shores which support a ship on the slip

Nogs, blocks of wood cut to the form

and size of bricks, and inserted in the interior walls of apartments as holds for the joinery

Nogs or *Nays*, in mining, square pieces of wood piled on each other to support the roof of a mine

Nogging, a kind of brick-work carried up in panels between quarters

Nogging-pieces are horizontal boards placed in brick-nogging, nailed to the quarters, in order to strengthen the brick-work

Nomades, in antiquity, wandering, rude, or savage tribes

Nomenclature, the art of naming; a vocabulary or dictionary of technical language peculiar to any art or science

Nonagon, a figure of nine sides and of as many angles

Non-condensing Engines are those made without that part of the machine called a condenser, and without those contrivances essential to the ordinary construction of engines that condense the vapour into fluid. In non-condensing engines the steam escapes into the atmosphere, after having acted upon the piston. The effect is measured by the excess of the pressure of the steam upon the piston, less the friction of the engine above the pressure of the atmosphere.

Non-conductors, substances through which the electric fluid passes with considerable difficulty or not at all; such as glass, resin, sulphur, silk, hair, wool, the air, &c.; but these become electric by friction

Nones, in the Roman calendar, the fifth day of January, February, April, June, August, September, November, December; and the seventh of March, May, July, and October

Noria, an hydraulic machine, common in Spain for raising water. The engine consists of a vertical wheel of 20 feet diameter, on the circumference of which are fixed buckets, for the purpose of raising water out of wells, &c., communicating with a canal below, and emptying it into a reservoir above, placed by the side of the wheel. The buckets have a lateral orifice, to receive and discharge the water. The axis of the wheel is embraced by four small beams, crossing each other at right angles, tapering at the extremities, and forming eight little arms. This wheel is near the centre of the horse-walk, contiguous to the vertical axis, into the top of which the top beam is fixed; but near the bottom it is embraced by four little beams, forming eight arms similar to those above described, on the axis of the water-wheel. In the movement of the horse or mule, these horizontal arms, acting on cogs, take hold, each in succession, of those arms which are fixed on the axis of the water-wheel, and keep it in rotation.

Norma, a square for measuring right angles, used by carpenters, masons, and other artificers, to make their work rectangular

Normal line, in geometry, a phrase used for a perpendicular line

Norman Architecture. In Normandy, in the tenth century, when the Normans occupied Neustria, the churches in other parts of France were in imitation of the Roman style. The plan of the buildings came from Rome, and the round arches, the pillars, and the mouldings, which were employed in their construction, had the same origin. But the corrupt taste of a less civilized people covered the capitals and the portals with a crowd of such appalling images as a wild fancy was likely to suggest, and a rude hand to portray.

The Normans, adopting the habitual plan and the established style, rejected the meretricious accessories, and resolved to trust for success to the two great principles of size and elevation. The oldest of the Norman churches are the plainest, but even these aspire to dimensions which could not fail to command admiration. Their

racter is severe but sublime. At the same time, the Normans had the boldness to insist upon an addition to their churches, which is admitted to be the grandest feature and the chief ornament of ecclesiastical buildings—the central tower. Towers had, fortunately, become an integral part of churches before the Normans began to build in Neustria, but the few towers which at that time existed in other parts of France only adorned the western end. Size, elevation, simplicity, and strength, together with the central tower, are the architectural peculiarities to which the Normans, as contradistinguished from the Franks, possess undeniable claims.

Norman workmanship was, at first, remarkable only for its solidity. The walls were often built of rubble, faced with small squared stones,—a manner of building which had been copied from the works which the Romans had left behind them in France. The pillars were, of course, composed of larger blocks. By degrees, and in buildings of importance, larger blocks were employed in the walls; but the joints were wide, and the mortar was coarse. In the time of William the Conqueror, greater neatness was accomplished; the stones were squared, and the courses regular; but the joints were still rather wide, and the mortar unsifted.

Another mode of construction was with long, narrow stones, which were placed, not in horizontal courses, but alternately inclined to the right and left. This, from the appearance it presented, was called the herring-bone fashion. It did not remain in use much after the eleventh century.

The Norman walls were of great thickness, and were filled up with *small stones, amongst* which mortar *was poured in hot.* This was called *grouting;* and in time the whole *mass so* hardened together as to acquire the consistence and strength of a solid rock. Such walls stood in no need of buttresses, through the means of which more advanced science afterwards obtained an equal amount of power at less labour and less expense. Buttresses, however, appear on the exterior of early Norman buildings, but seem to have been introduced only to relieve the baldness of the surface. They project so slightly that they can add but little support. In early Norman buildings the buttresses never rise above the cornice.

The plan of the early Norman churches is always that of the basilica, with a semicircular recess at the end, which recess formed the choir. The larger churches have transepts and side aisles which are divided from the nave by arcades. The small churches have often neither side aisles nor transepts. The arches of the nave either rest on piers, to which half-pillars are attached, or on single pillars, but hardly ever on those huge cylindrical piers which are commonly seen in the Norman churches of England. Indeed, the thick cylindrical piers of England are scarcely to be met with in all France, except in one or two crypts, where the known superincumbent weight justifies the preference of strength to beauty.

In the churches of France, single pillars preceded piers; the exact reverse of what might have been expected, were it not recollected to what an extent and degree France had become Roman, previous to the inroad of the Northern conquerors. The pillars have always capitals, which, at first, were perfectly plain; but, from the beginning of the eleventh century, were enriched with different kinds of foliage, to a certain degree departing from, but still seeking to imitate, the Roman models. The half-pillars, which are attached to the ends of the piers, are always set

back in recesses, or sinks; the same is the case with the small pillars on the outside of the windows, as also with those of the portals. This is a characteristic between the Norman style and the Roman—the Norman pillars are recessed; the Roman project.

The windows are always round-headed, and undivided; and, externally, have on each side a small recessed pillar, which supports an impost and moulding.

In the gable, over the entrance door of churches, a small circular window is sometimes introduced.

The windows of castles and of domestic buildings are usually divided by a single shaft.

The portals are round-headed, and were gradually enriched by an increasing number of semicircular mouldings. The most common mouldings are the billet, the nail-head, the chevron, the zigzag or embattled frette, hatchet, nebule, star, rope, beak-head, dog-tooth, and, occasionally, different sorts of foliage, as the vine, the bay, the ivy, &c. (See *Frontispiece.*)

The external cornice, under the eaves of churches, was sometimes a moulding describing a series of semicircles, under a projecting course, and sometimes a series of blocks. The ornamented corbels, on the exterior of churches, were adopted by the Normans before imagery was admitted into the interior of the edifice.

The roofs of the early Norman churches were of wood, except the part over the semicircular chancel, which from the first was vaulted with stone. The side aisles were also vaulted with stone; as were, sometimes, the comparatively small naves of village churches. The vaulting was composed either of small stones let into a bed of mortar or of tufa, or of a light calcareous stone, which is found in many parts of Normandy. The most ancient vaulting is without ribs, and the most ancient ribs are without mouldings.

The dome vaulting over the side aisles of the abbey church at Bernay is the only specimen of the kind in Normandy.

The first and purest Norman style prevailed till the latter part of the reign of William the Conqueror, from the early part of the tenth till nearly the end of the eleventh century.

The abbey church of Bernay, begun in the first half of the eleventh century, is the oldest Norman building of any consequence which remains in its primitive form. The architecture of the interior is plain to baldness, but the dimensions are imposing.

The abbey churches of Jumiéges and Cerisy were begun in the first half of the eleventh century. The Norman portions of the cathedral, and of the church of St. Taurin, at Evreux, as also of the church of Mont St. Michel, belong to the same period.

St. Georges de Boscherville, and the two great churches at Caen, are splendid examples of the architecture of the time of William the Conqueror.

In all these buildings the character of simplicity is preserved, but some ornament in the details begins to make its appearance before the close of the Conqueror's reign, as, for instance, in the embattled frette moulding round the arches of the nave of Matilda's church at Caen, in some parts of St. Georges de Boscherville, and other places.

The florid Norman was already developed in the early part of the twelfth century. Of this style a rich specimen is afforded in the arcade of the nave at Bayeux. The arches are ornamented with a multiplicity and variety of mouldings of intricate design and elaborate execution.

Another specimen of the flor

Norman exists in the neighbourhood of Bayeux, in the church of St. Gabriel, built by Robert of Gloucester (1128).

The abbey church of Montivilliers (1117), and the church at Graville, are instances of the florid style in all its exuberance.

Norman Architecture in England. Of the architecture which existed in this country previous to the introduction of the Norman there are no certain vestiges. The most competent authorities have decided that hardly any thing which can be proved to be Saxon remains in existence. Parts of a few churches, which have all the marks of a very remote antiquity, and of which the style differs materially from the Norman, may be suspected to be Saxon. Their distinguishing features are a ruder imitation of the Roman, projecting, instead of recessed pillars, and the combination of diagonal with perpendicular forms in the external ornaments of towers. Such is the case at the old church of Barton, in Lincolnshire, and at Earl's Barton, in Northamptonshire.

Some persons have imagined that the generality of the Saxon churches were merely timber buildings, but this appears to be a mistake; for in Domesday Book, which takes note of 1700 churches, one, and only one, is specified as being built of wood; and Henry of Huntingdon, speaking of a particular church, says, "It was not built of stone, but of wood, and covered with reeds, as is the custom in Scotland;" demonstrating that it was *not* the custom in England.

Not only were the Saxon churches not merely timber buildings, but some of them were constructed at a considerable expense, and with much architectural ornament.

In the seventh century, a church was built at Lincoln, which Bede says was of stone, and of good workmanship. The church of the monastery of Wearmouth was erected in 675, by Abbot Benedict Biscopius, a noble Northumbrian, who, at twenty-five years of age, detached himself from the service of King Oswy, and embraced a religious life. He brought over masons from France to build his church in the Roman manner, and, when the building was nearly finished, he procured artificers from the same country, skilled in the mystery of making glass, to glaze the windows.

The conventual church of Ripon, and the cathedral church of Hexham, were both built by Wilfrid, Bishop of York, in the second half of the seventh century; and were both constructed of stone, and supported by pillars and arches. Wilfrid also imported builders and artists from abroad—from Rome, Italy, France, and other countries.

In the eighth century, the monastery of Croyland was built by Ethelbald, King of Mercia; and the church of St. Peter at York was rebuilt by Archbishop Albert, and consecrated just before his death, which took place in 780. Alcuin describes this church as having pillars, arches, and porticoes.

In the ninth century, the progress of the arts was interrupted by the constant incursions of the Danes. All that had been done was destroyed; and little more than repairs, and military works, could be undertaken till the peaceable reign of Edgar, in whose time the abbey of Ramsey was founded, and the church built by Ailwin, then alderman of all England. This church was built in six years, and finished in 974. It was in the form of a cross, and had pillars, arches, and two towers, one of which was supported by four pillars, or piers, in the middle of the building. This appears to have been the first English church that

had a tower so situated, or that was built in the form of the cross.

From these descriptions of the Saxon churches, preserved in the early chronicles, it appears that the Saxon style was, like that of every other country, an imitation of the Roman. The abbey church of Ramsey, which was one of the latest, and one of the most celebrated of the works of the Saxons, was completed in six years. The last Saxon work of importance was the abbey church of Westminster, built by Edward the Confessor, and finished and consecrated in 1065, one year before the Conquest. This church is represented to have been of a different character from that of any preceding structure in England; and this difference undoubtedly consisted in an approximation to the Norman method of building. Edward the Confessor had been brought up in Normandy, and was almost reproached for his incessant endeavours to introduce Norman customs and manners.

The churches and monasteries which arose after the Conquest were constructed after a new manner of building. From all this it appears that there must have been a marked difference between the Saxon and the Norman fabrics. But, as both were an imitation of the Roman, the difference must have consisted in the dimensions and the superior workmanship and magnificence of the new structures. It must have been the same style on a grander scale, and executed in a more scientific manner.

At the time of the Conquest the Anglo-Saxons were in every respect a ruder and less civilized race than the Normans had by that time become.

The earliest work of the Normans which exists in this country was conducted by Gundulph, who, *after rebuilding his cathedral at Rochester, was employed by William to superintend the construction of the White Tower, in the Tower of London, which contains within its walls perhaps the only ecclesiastical remnant of the Conqueror's time at present in existence.*

In the course of the Conqueror's reign, several cathedrals, abbeys, and castles were built, none of which remain in their original state. A remnant of the Conqueror's time existed at Canterbury till within these few years,—the northern tower, at the west end of the cathedral. This was a part of the work of Lanfranc. The stones of which it was built were irregular, and the joints between the courses were wide.

Several castles have the reputation of being of the Conqueror's time, but, on a close investigation, will be found to have been rebuilt in after years. Such is the case with the castles of Norwich, Rochester, the keep at Conisborough, and many others.

Within less than a century after the Conquest almost all the cathedrals and abbey churches of England, besides innumerable parish churches, were either wholly rebuilt or greatly improved by the Normans, on whom William and his successors conferred all the best ecclesiastical preferments. By the introduction of these Norman prelates, the Norman style was rapidly diffused, at first, however, so much affected by the state of art in this country, as to give to the English building the character of a Norman building of much greater antiquity.

Rufus was a great builder; his principal work was the great hall of his palace at Westminster. This hall, as it now exists, was altered by Richard II., but much of the original work was left, and during the late repairs, portions of this were visible. The lower part of the walls was faced with rubble; the courses were irregular; the joints wide. Remains of a tr

forium or gallery were discovered, which had been carried along the sides of the hall, half-way up. The capitals of the pillars on which the round arches of this gallery rested were plain cubes. The whole of the workmanship was coarse.

The plan of the churches erected about this time was the same as in Normandy. All were built with the semicircular chancel, which in England afterwards fell into such general disuse that few traces of its existence are to be found in this country. It is, however, to be traced in that of St. Bartholomew-le-Grand, in London, (begun in 1123,) in the minster at York, at East Ham, Essex, and in other places.

The arches of the nave usually rested on those heavy cylindrical piers which in French churches are ever hardly to be found, except in crypts. Their prevalence in England must be ascribed to the inexpertness of the native workmen, and the probability is, that they had previously been adopted by the Saxons from their inability to imitate the Roman style in a more satisfactory manner. Sometimes, to adorn the cylindrical piers, the Anglo-Normans introduced the spiral groove winding round them, with the net or lozenge-work spreading over them.

The windows and the doors were the same as in Normandy, and the Norman mouldings were gradually introduced with little alteration.

The walls are remarkably thick, and without prominent buttresses.

Specimens of the time of Rufus are to be seen in the choir, side aisles, and middle transept at Durham; in the walls of the lower part of the western façade of Lincoln; the towers and transept of *St. Alban's;* the oldest remaining *parts of* Winchester; and the east *end and cross* aisle of Worcester. *The walls* in this reign were irregularly built, and the joints continued to be wide, as may be seen at Durham, Lincoln, Winchesand, other places.

The style prevailed in the early part of the reign of Henry I., as may be seen by the ruins of St. Botolph's priory, Colchester, which was built by Ernulph, a Norman monk, in the first years of that prince. Here are the same heavy cylindrical piers, the same stumpy proportions, the same poverty of mouldings. But in the course of this reign an impulse was given to architecture by one of those men of genius who affect the character of the age in which they live. Roger Poor, Bishop of Salisbury, a Norman by birth, and combining in himself the offices and the qualities which, in those times of constant commotion, were often united, was much distinguished as a prelate, a warrior, a statesman, and an architect. William of Malmsbury relates, that the walls which were built under the superintendence of Roger of Salisbury were so smooth, and had such fine joints, that they seemed to be made of a single stone. Had fine joints been in use before, their appearance in the works of this prelate would not have been so much extolled. The admiration with which they are mentioned gives us the date of the first introduction of fine joints in the walls of English buildings. From this time progressive improvement took place in other parts of the fabric. Something like decoration was added. The portals began to be enriched. The architecture of England ascended to the level of the architecture of Normandy in the time of William the Conqueror.

Examples of the style of this reign may be seen in the naves at Gloucester, Norwich, Ely, Durham, and Southwell; also in the lateral towers of Exeter cathedral, built by Bishop Warlewast; in St. James

tower, Bury St. Edmund's; in the ruins of the chapter-house at Rochester, built between 1114 and 1125, by the same Ernulph who built St. Botolph's at Colchester, and who, on the death of Gundulph, was promoted to the see of Rochester; in the portal of the round church at Cambridge; in the nave of the church at Dunstable; in Saint Bartholomew-le-Grand, London, which was begun in 1123; in St. Sepulchre's, Northampton, built by Simon de Liz, second earl of Northampton, on his return from the Holy Land, and who died in 1127; and in the abbey church of Tewkesbury, begun by Robert Fitz-Hamon, (who died in 1107,) and consecrated in 1123.

Examples.—Portal of the chapter-house at Durham, built by Bishop Galfrid Rufus, between 1133 and 1143; church of Castle Acre priory, Norfolk, consecrated in 1148; church of St. Cross, Hampshire; Ripon minster; St. Frideswide, (now Christchurch,) Oxford, begun not later than 1150, and finished in 1180.

About this time, or a little later, Domestic architecture began to make its appearance in England, though, from the dimensions and arrangement of some of those buildings which have come down to our time, it is difficult to determine whether all of them were destined for dwelling-houses, or were only halls for public occasions, or for the courts of the feudal lords.

Of these buildings the invariable plan is a parallelogram of two stories; sometimes a double parallelogram. The lower story was vaulted, as we have seen to have been the custom in Normandy, and it had no internal communication with the upper story. The upper story was approached by an external staircase, which probably was *moveable. The only fixed* Norman *staircase now extant is the one at Canterbury.*

The probability is that the lower story was occupied by the servants, and the upper story by the masters; but in none of the buildings of this time now extant do there exist any traces of subdivisions.

An example of Norman Domestic architecture existed in Southwark till within these few years. It was the hostelry or town residence of the priors of Lewes. The church of St. Olave, Southwark, was confirmed to the prior and convent of Lewes by William, second Earl Warren and Surrey, the son of the founder. Earl William died in 1138. It appears, however, that the priors of Lewes rented a building in 1170 and 1186, for their occupation in London; from whence it may be concluded, that the hostelry in question was not built till after that period. The general features of the portion of the hostelry which remained till lately nearly resembled those of the manor-house of Boothby Pagnel, Moyse's Hall, at Bury St. Edmund's, and the building which is called the Pythagoras School at Cambridge.

In 1826 was still existing at Barneck, in Northamptonshire, a Norman manor-house, which was not built for defence. In this instance the hall, which was the principal feature, was on the ground floor, and had no vaults underneath. The hall consisted of a centre and two side aisles. The fine joints of the walls of this building denoted that it could not have been built much before the middle of the twelfth century.

At Bury St. Edmund's is a Norman domestic building, which goes by the name of Moyse's Hall.

At Boothby Pagnel, in Lincolnshire, is a Norman manor-house on nearly the same plan. In this are a fire-place and a chimney, which indicates that the building of which it forms a part cannot be older than the second half of the twelfth century. This edifice has windows;

the ends as well as the sides,—a circumstance which makes it evident that to this building no others could have been attached. It is surrounded by a moat.

At Christchurch, Hants, is a Norman remnant which has also a chimney.

At Lincoln is a Norman domestic building which goes by the name of 'John of Gaunt's Stables,' but which, in fact, was the public meeting-house of a guild. It is so much enriched as to be placed late in the reign of Henry II.

These examples prove that about the middle of the twelfth century, mansions, distinct from castles for defence, began to be erected in England; and that, independent of colleges, abbots' lodgings, and the habitable parts of convents, instances existed of Domestic architecture. But it was long before dwelling-houses acquired a character bearing any relation to the quality of the proprietor, or were constructed with much regard to convenience.

Examples of the Norman style of the time of Henry II. are to be seen in the abbey gateway, Bristol; in the Galilee, or chapel, at the west end of Durham, built by Bishop Pudsey (1154 to 1197), together with the lateral portals of the nave; in the new nave and great west portal of Rochester, &c.

It was in the latter years of the reign of Henry II. that the struggle between the Round and the Pointed styles, which is called the Transition, began to take place in this country.

Kirkstal abbey, in Yorkshire, was built in the thirty years preceding 1183. The nave arches are pointed, but the pillars are massive, and the windows and portals are round. The church at Roche abbey, though *equally in the Transition* style, and *having round-headed* windows *above pointed* arches, Norman *mouldings and* capitals, yet is of a less heavy character. Both buildings, however, denote that during those years the new style was only just beginning to be received in England.

About the same time (1170), Archbishop Roger employed the Pointed style in the new crypt of York minster.

But the early examples of the Transition, of which the dates are known with the most undoubted certainty, are the round part of the Temple church, London, which was consecrated in 1185, and the choir of Canterbury cathedral, which was rebuilt after the fire in 1175, and in which the Pointed style was introduced by John of Sens, a French architect. Other instances are to be found in the great tower at the west end of Ely, built by Bishop Ridel, who died in 1189; in the county hall of Okeham, Rutlandshire; in the abbey church of Glastonbury, &c.

But the nave of Rochester and the nave of Peterborough, rebuilt between 1170 and 1194, are proofs that the old fashion was not at once superseded by the new.

Simultaneously with the introduction of the Transition style, hewn stone vaults appear to have been first thrown over the wider parts of English churches, which till then had been habitually roofed with wood. A stone vault was thrown over the new choir of Canterbury, in 1174. It was customary before that time, to roof narrow spaces with plain cross-vaulting, but not to vault wide spaces with stone. Plain cross-vaulting of rubble, with and without ribs, had been adopted before in crypts, side aisles, and chancels. Barrel-vaulting, we have seen, was introduced in the time of William the Conqueror. From the time that the choir of Canterbury was built, which was not long after, it became common to throw stone vaults over the naves of the larger churches of

Normandy, and hewn stone vaults, plain at first, and gradually enriched, became habitual in England. Prominent buttresses and flying buttresses, as in Normandy, followed in the train of the stone roofs.

From this time, the Round style fell gradually into disuse; but at Fountain's abbey, the foundations of which were laid in 1204, and which was in progress during the forty subsequent years, the windows and portals are still round-headed; and an instance of a round portal is to be found at Ketton, in Rutlandshire, so late as 1252.

During the reign of Henry III. the Early Pointed style attained its most perfect condition. Fine examples of this style are to be seen in the chapter-house, the transepts, and part of the choir of Westminster abbey; in the choir of St. Alban's; in the nave of Lincoln; east end of Durham; nave of Worcester, 1224; nave and spire of Lichfield; south transept of York; and the older part of the choir of Southwell; and in Salisbury cathedral, which was begun in 1221, and carried forward, without interruption, till it was completed.

The establishment of the Pointed style was attended with one remarkable difference in England and Normandy. In Normandy, the semicircular chancel became, generally speaking, polygonal; in England, generally speaking, it became square. Polygonal chancels are as rare in England as square chancels are in the larger churches of Normandy; and this difference of shape in England afforded the opportunity of those magnificent east windows, which are so principal and so splendid a feature of our cathedrals. Another difference to be remarked, is the battlement, which usually forms the parapet of *English churches, and* which never *occurs in the ecclesiastical buildings of France.*

It may be said,—1. That the supposed existence of the Pointed style in Normandy, in 1056, is imaginary. 2. That the Normans, adopting the corrupt Roman style, gave it a character of their own. 3. That the Normans greatly contributed to the advancement of the arts in England. 4. That architecture performed exactly the same revolution in England and France, France having, in all the changes, a certain precedence.

Norroy, or *North roy*, in heraldry, one of the two provincial Kings at Arms, whose jurisdiction lies on the north side of the Trent, as does that of Clarencieux to the south

Northampton Tables, Tables made at the county town of Northampton, formed from the registers of burials of that locality, from which calculations were made of the value of life, for the purpose of its insurance. (See article *Assurance.*)

Nosing, the prominent edge of a moulding or drip; the projecting moulding on the edge of a step

Nosing of steps, the projecting parts of the tread-board or cover, which stand before the riser. The nosing of steps is generally rounded, so as to have a semicircular section; and in good staircases a hollow is placed under them.

Notch-board, a board notched or grooved out, to receive and support the ends of the steps of a staircase

Notching, the cutting of an excavation throughout the whole breadth of a substance: by this means timbers are fastened together, or their surfaces, when joined at angles, are made to coincide

Nozzles, those portions of a steam engine in which are placed the valves that open and close the communication between the cylinder and the boiler and condenser, in low-pressure or condensing engines; and between the cylinder and boile and atmosphere, in high-pressu or non-condensing engines

Nucleus, the internal part of the flooring of the ancients, consisting of a strong cement, over which was laid the pavement, which was bound with mortar

Nuisance, any thing tending to hurt, to annoy, or to endanger health. (See the excellent work by Mr. Gibbons on this subject.)

Nullah, in India, a natural canal, or small branch of a river

Nunnery, a Roman Catholic building for an association of nuns or females devoted to a life of religious seclusion. Previous to the Reformation, there existed in England 127 edifices for the convenient lodging of such pious women, 2 in Wales, and 20 in Scotland; in the whole in Great Britain, 149. But there were many convents and religious houses not specially named nunneries, but which were receptacles also for such purposes.

Nunnery, a term sometimes applied to the triforium or gallery between the aisles of a church and the clerestory; so called from the situation of the nuns' choir in some convents. At the present time, the roomy galleries over the aisles in Westminster abbey are called nunneries, probably from having been used by the nuns of Kilburne, when they visited the abbey, to which they were subordinate.

Nut, a short internal screw, which acts in the thread of an external screw, and is employed to fasten any thing that may come between it and a flange on the bottom of the external screw or bolt

OAK OBE

Oak. There are two kinds of this timber common in England, on the Continent, and in America. Oak of good quality is more durable than any other wood which attains the same size: its colour is a well-known brown. Oak is a most valuable wood for ship-building, carpentry, frames, and works requiring great strength or exposed to the weather. It is also much used for carved ornaments, panelling of rooms, pulpits, stalls, and standards for churches. It is likewise used in the construction of all kinds of buildings, for strength and stability. English oak is one of the hardest of the species: it is considerably harder than the American, called white and red Canada oak. African oak is well adapted to the construction of merchant vessels. Italian oak is much purchased for our dockyards, to the prejudice of that which is proudly standing in our several forests.

Obelisk, in architecture, a quadrangular pyramid: those of Egypt may be described as large stones, quadrilateral, diminishing from the base upwards, till, within about a tenth of the height, the sides converge to a point. The width of the base is usually about a tenth of the height, to that part where the sides begin to converge: they are commonly formed from a single stone, mostly of granite. There are, however, two small obelisks in the British Museum, formed of basalt, and one at Philæ, of sandstone. When obelisks were first made in Egypt, it was customary with the patriarchs of the Jews to set up stones to perpetuate the memory of great events. Strabo calls such stones 'books of history;' an epithet which might be applied with propriety to the inscribed Egyptian obelisks. The date of the Flaminian obelisk, which is covered with hieroglyphics, is by some writers supposed to be between 1580 and 1600 B.C. The first obelisk was raised by Rameses, King of Egypt, in the time of the Trojan war: it was 40 cubits high, and employed 20,000 men in building. Phiua, another king of Egypt, raised one of 45 cubits, and Ptolemy

Philadelphus another of 88 cubits, in memory of Arsinoë, &c. The Romans also erected many, which are well described in Roman history.

Oblate, flattened or shortened; in geometry, a term applied to a spheroid, produced by the revolution of a semi-ellipsis about its shorter diameter. Of this figure is the earth, and probably all the planets, having the equatorial diameter greater than the polar.

Oblique, in geometry, aslant; not direct; not perpendicular nor parallel

Oblique angle, one that is greater or less than a right angle

Oblique-angled triangle, one that has no right angle

Oblique arches, or *Oblique bridges*, are those which conduct high roads or railroads across a river, canal, &c., in an oblique direction: they are also called *'skew arches*

Oblique line. When one straight line stands upon another, and makes unequal angles therewith, the angles are said to be oblique, the one being greater than a right angle, and the other less: hence a line is only oblique as it relates to another line; otherwise the word would be destitute of meaning.

Oblique sailing occurs when a ship, being in some intermediate rhumb between the four cardinal points, makes an oblique angle with the meridian, and continually changes both its latitude and longitude

Oblong, a rectangle of unequal dimensions; in geometry, longer than broad

Observatory, a building erected for the purpose of making observations on the motions of the heavenly bodies. More particularly with reference to the study of Terrestrial Magnetism, observatories have been erected by the British Government in Canada, St. Helena, the Cape of Good Hope, and Van Dieman's Island; by the East India Company at Madras, Singapore, Simla, and Trevandrum; and by the Russian Government at St. Petersburgh and other places, in connection with those at Gottingen, &c. The most munificent example of private devotion to the science of Astronomy is the splendid observatory erected by Lord Rosse at Pensantown, in Ireland.

Obtunding, the blunting or taking away a sharp corner

Obtuse, in geometry, blunt; in opposition to acute or sharp

Obtuse angle. In geometry, if the contained angle be less than a right angle, it is called an acute; if greater, it is called an obtuse angle.

Obtuse-angled triangle, a triangle which has an obtuse angle

Obtuse section of a cone, the hyperbola of ancient geometricians, because they considered it only such a cone whose section through the axis was an obtuse-angled triangle

Occus, the banqueting-room of a Roman house. There were several kinds of occi, viz. Corinthian, tetrastyle, Cyzicene, and Egyptian. In the Greek houses the occi were spacious apartments, in which the mistress of the family employed herself and servants at the loom

Ochre, brown, a clay coloured brown by the oxide of iron

Ochre, red, a clay coloured red by the oxide of iron

Ochre, yellow, a clay coloured yellow by the oxide of iron

Octagon, a figure of eight sides and as many angles: when all the sides and all the angles are equal, the figure is called a regular octagon

Octahedron, in geometry, one of the five regular bodies, consisting of eight equal and equilateral triangles

Octostylos, a portico which has eight columns in front

Odeum, a small theatre for the recitation of musical compositions, generally in the neighbourhood of the theatre: the odeum at Athens was contiguous to the theatre of Bacchus; the odeum at Pompeii also joined the theatre

Odontograph, a very ingenious instrument, invented by Professor Willis,

of Cambridge, to enable the millwright, workman, and engineer to measure, draw, and design infinitely in extent, the teeth of wheels

Œcus, according to Vitruvius, apartments near or connected with the dining-room

Offices, as connected with the domestic purposes of large mansions, palaces, &c., consist of kitchens, sculleries, pantries, breweries, washhouses, &c.; frequently detached or out-houses, and sometimes, in cities, underground and vaulted places beneath the same roof

Offices, as connected with business, are apartments for the accommodation of clerks or accountants; merchants' counting-houses, &c.; for law clerks, law agents, &c.

Offing, in navigation, that part of the sea distanced from the shore where there is deep water, and no necessity for a pilot

Offset, or *Set-off*, the splay or narrow slanting course of stone or brick, serving to connect two portions of a wall, the uppermost of which recedes from the face of that beneath

Ogee, a moulding consisting of two members, the one concave, the other convex; the same with what is otherwise called cymatium. In Gothic architecture, ogees are very much employed. The term ogee is also applied to a pointed arch, the sides of which are each formed of two contrasted curves.

Ogives, arches or branches of a Gothic vault, which, instead of being circular, pass diagonally from one angle to another, and form a cross with the other arches which make the side of the squares, whereof the ogives are diagonals. The middle, when the ogives cut or cross each other, is called the key, sometimes carved in the form of a rose. The members or mouldings *of the ogives* are called nerves, *branches*, or veins; and the arches *which* separate the ogives, double arches.

Oillets, or *Oylets*, small openings or loopholes, sometimes circular; extensively used in the fortifications of the middle ages

Oliver, a small lift-hammer, worked by the foot. The hammer head is about 2½ inches square and 10 inches long, with a swage tool having a conical crease attached to it, and a corresponding swage is fixed in a square cast-iron anvil-block, about 12 inches square and 6 deep, with one or two round holes for punching, &c. The hammer handle is about 2 to 2½ feet long, and mounted in a cross-spindle nearly as long, supported in a wooden frame between end-screws, to adjust the groove in the hammer face to that in the anvil-block. A short arm, 5 or 6 inches long, is attached to the right end of the hammer axis; and from this arm proceeds a rod to a spring-pole overhead, and also a chain to a treadle a little above the floor of the smithy.

Olympiad, a period of four years, by which the Greeks reckoned their time. The first Olympiad corresponds with the 775th year before the birth of our Saviour, and 22 years before the building of Rome.

Oolite, the Portland stone used in architecture, called also freestone and roestone

Opa, according to Vitruvius, a bed or cavity in which the head of a tie-beam rests

Opaque, cloudy, not transparent

Ophites, a black marble

Opisthodomos, the enclosed space behind a temple: the treasury at Athens was so called, because it stood behind the temple of Minerva

Oppidum, according to the Romans, a mass of buildings; an entrance to a town; the façade to a public building; not unlike to the termini on the principal lines of railway

Opposite angles, those which are formed by two straight lines crossing each other, but not two adjacent angles

Opposite cones are those to which

straight line can be every where applied on the surface of both cones

Opposite sections, those made by a plane cutting two opposite cones

Optics, the science of direct vision, including catoptrics, dioptrics, and perspective.

Optostrotum, according to the Greek, a brick-paved flooring

Opus, Roman reticulated masonry; a mode of workmanship

Or, in heraldry, gold: it is denoted in engraving by small points all over the field or bearing

Ora, a Roman hawser

Oratory, a small private chapel or closet for devotion

Orb, a mediæval term for a blind window

Orbs, in Gothic ornament, bosses and knots of foliage, flowers, or other ornament in cornices

Orbiculus, according to Vitruvius, a roller or a pulley revolving upon an axis, and having a groove in its circumference for the rope to fit into; employed as a mechanical power for raising or drawing

Orchestra, the area in the Greek theatre comprised between the lower range of seats and the proscenium. In the Roman theatre, the orchestra was appropriated to the senators; but in the theatres of the Greeks it was the scene of action of the dancers.

Orders of Architecture, usually named the 'five orders,' without reference to other styles of architecture, are thus enumerated by most writers: 1. Tuscan. 2. Doric. 3. Ionic. 4. Corinthian. 5. Composite. (For their proportions, see *Architecture*.)

Ordinates, in geometry and conics, lines drawn from any point of the circumference of an ellipse, or other conic section, perpendicularly across the axis, to the other side

Ordnance Survey of Great Britain and Ireland: a work of great importance in ascertaining the true geographical position of our islands and of their varied superficial features. This survey originated in the mutual desire on the part of English and French philosophers to determine the precise difference of longitude between the meridians of the Greenwich and Paris observatories. In the pursuit of this object, a meeting was arranged at Dover between three members of the French Academy, MM. Cassini, Mechain, and Legendre, and General Roy and Dr. Blagden, to arrange plans of operation. In the course of the subsequent survey, the Officers of the Royal Artillery, to whom the superintendence of the work was intrusted, extended their views and operations, and, under the patronage and at the expense of the Board of Ordnance, proceeded to determine the length of as many degrees on the meridian as came within the limits of the survey. The rules by which the main lines for this and all other extended surveys are obtained, are derived from the principles of trigonometry, or the properties of triangles. By these principles we are enabled to compute the exact form and dimensions of any triangle from the actual measurement of one side only, and of the angles formed at its extremities by the other sides. Upon these principles the true figure and size of our globe have been determined upon the relative lengths of degrees of a meridian in different latitudes.

The exactness of the results of these operations depending upon the correct measurement of the one side, or *base line*, and of the angles at its ends, formed by the two imaginary sides which have a common meeting point in some distant and conspicuous object, the apparatus for measuring this side and the angle is required to act with extreme delicacy and exactness. For measuring the length, rods of various materials have been used, and endeavours made to obviate the effect of changes

temperature in altering the length of the rods themselves. General Roy commenced the measurement of a base line on Hounslow Heath with rods of deal, each twenty feet long. But these rods, although prepared in the most careful manner, of the best seasoned timber, perfectly straight, and effectually secured against bending, were found to suffer such changes of length, from the varying dryness and moisture of the air, as rendered them utterly unfit for the purpose, and glass tubes were eventually substituted, each of them twenty feet long, and enclosed in a frame of wood, allowing only expansion or contraction in length from heat or cold according to a law ascertained by experiments. With these rods a base of about 5⅓ miles in length was measured so exactly, that a remeasurement by Colonel Mudge several years afterwards, made with a steel chain constructed by the celebrated Ramsden, differed only from the original line to the extent of 2¾ in. Steel chains are jointed similar to a watch-chain, and are always used with uniform tension, the differences in length due to temperature being calculated upon the observed fact, that each degree of heat above 62 Fahr. extends the chain ·0075 of an inch.

For determining the angles, the English Officers used an excellent theodolite by Ramsden, having both an altitude and an azimuth circle, and a telescope of great power. This instrument, combining the powers of a theodolite, a quadrant, and a transit instrument, is capable of measuring horizontal angles to fractions of a second. It is recorded among the proofs of the accuracy attained in this triangulation, that a testing *line, or base of verification*, as *termed in* geodesic operations, *measured on* Salisbury Plain, of *which the length* exceeded seven miles, differed only *one inch* from the computation carried through the series of triangles from Hounslow Heath to Salisbury Plain.

When the primary triangulation had been thus carefully completed, a further subdivision of each of these great triangles was performed, and each of these again was subdivided into others, so that the entire plot of the country was represented by a complete net-work of triangles. Each of these divisions and subdivisions being formed independently of the others, and yet the exact accordance of the whole being insisted on and effected, accuracy is secured in all these principal operations, and the filling in of each of these spaces is intrusted to a different class of operators, whose labours in producing the final plan are so divided and arranged that the work of each is a check upon the exactness of his predecessor. Thus the surveyors measure the lines and angles on the ground, but another class of assistants (the plotters) produce the plan from the records of the surveyors, and a third class (examiners) test the plan, thus produced, by subsequent comparison in the field. One effect of this system, by which the range of operations confided to each operator is thus limited, and the fidelity of these thus severely scrutinized, is, that the bulk of the work after the triangulation may be safely confided to an inferior and cheaply engaged class of assistants, and great comparative economy thus attained.

The Ordnance Survey of Great Britain and Ireland is plotted to different scales. Thus the whole of Ireland is plotted on a scale of six inches to a mile, and is contained on 1907 sheets of maps, which may be purchased at 2*s.* 6*d.* and 5*s.* each. The Survey of England and Wales is plotted on a scale of one inch to a mile, and

comprised in 110 sheets (of which ninety are already published), at 2*s.* each; about half of these are published in quarter-sheets at 6*d.* each. Portions of Lancashire and Wigtonshire are plotted at six inches to a mile, price 2*s.* 6*d.* and 5*s.* each; and the towns of Dublin, Wigan, Blackburn, Chorley, and Liverpool, upon the large scale of five feet to a mile, from 2*s.* to 3*s.* 6*d.* each. It is only the one-inch survey which has the hills shaded. A Geological Survey, which besides giving the one-inch maps geologically coloured, shows horizontal and vertical sections of the country, is also in progress, and is completed over some of the south-western counties.

The estimate for the recently completed Ordnance Survey of London was as follows:—"That a block-plan of the metropolis, and of the suburban districts included within a radius of eight miles from St. Paul's, may be executed, with a proper system of levels, for £24,215, and that the cost of engraving the block-plan, upon a scale of five feet to the mile, and upon 901 plates of double elephant size, would be (including £3,604 for the copper) £12,614., making together £36,829." The plan has been produced at a cost within this estimate, and the engraving will probably be executed considerably below the estimate.

Organ. This word is derived from the Greek *organon: organum* in Latin, *organo* in Italian, *orgue* in French, *orgel* in German. It signifies, generally, an instrument; but is now used for the name of the grandest and most worthy of musical instruments.

The tones of an organ are produced from the pipes only; of these some are of wood, others of various kinds of metal, and even of glass. *An organ of full compass may contain all the sounds recognized in the science of music,* from the lowest appreciable to the very highest. The largest pipes produce the lowest sounds, and some few are made as long as about 32 feet, while the smallest are about the size of the pipe of a very small key. Organs are of various kinds, viz. for the church, the concert-room, and for the private drawing-room. The church organ should be of a full, deep, and solemn character; while the concert-room organ should be of a lighter and more brilliant kind, with every variety of stop, in order to imitate, not only the full orchestre, but also certain 'solo' instruments. Hence we have the flute-stop; the hautboy, the cremona, or krum-horn; the vox-humana, &c. stops; according to the extent of the instrument. These solo, or fancy stops, belong only to the concert-room or drawing-room organ, and are wholly unbecoming in one for the church.

We have not space to give any thing like a description of this the noblest of instruments; and it must suffice to say that it consists of a bellows which supplies the pipes with wind by means of a wind chest; the wind being conveyed therefrom, through channels, under the different ranks, or rows of pipes, and thence into the pipes by means of pallets, or valves, opened at the pleasure of the performer, by pressing the proper lever or key.

The organ is a very ancient instrument of the church, and must have been very unwieldy, since we are told of one in the cathedral church at Halberstadt, which had only a few large pipes, and the keys were more than a handbreadth in width, and were beaten or pressed down by the fist, or elbow; the wind being supplied by several small bellows. We are also told of the Winchester organ which required seventy men to supply with wind; its compass was of

notes only, although it had 400 pipes, *i. e.* forty to each note; it was so loud that it could be heard all over the city. The organ is usually described as being of three kinds; the great, or full chorus organ; the swell organ, and the choir organ: the latter is used to accompany the softer parts of the music, and is such an instrument as was carried in the ancient processions, in the rogation days, and other seasons, to accompany the priests with while chanting the litanies; the performer, or, more properly speaking, the minister at the organ, being carried also with the instrument, and seated: hence this organ was called the chair-organ, now corrupted into choir-organ, from the difference in its employment. The swell organ is used chiefly to accompany solos; for interludes, and such like fanciful music, and takes its name from being able to swell out its sounds by openings made by turning a series of boards, on their centres, similar to a Venetian blind, these boards being connected by levers under the control of the performer's foot.

The key-board, or row of keys of an organ, are like those of a piano-forte, only they require to be pressed down, (not struck like those of the latter instrument,) so as to open the pallets before mentioned, and cause the pipes to speak. A complete church organ contains three rows of keys, one for each of the above-mentioned organs; and most organs have also a row of keys called pedals, to enable the organist to play the bass-notes with his feet.

In organs that are played by means of a wind, or handle, the part of the organist is performed by a cylinder, on which are placed a number of wires so contrived as to press upon the levers, and open the pallets or valves; and hence those instruments are called barrel organs. They are of little or no use for the purposes of the church. It has been the fashion for some time, to make one organ do the work of two, namely, the full organ and the choir organ: but it is at best but a sorry contrivance; for in such an organ there can be no good choir organ mixture; and the full organ is generally too noisy, the fullness being made up of loud-voiced pipes, instead of their being round, mellow, and full-toned. These kinds of organs have not the dignified and solemn character necessary for real church music.

Organ screen, an ornamental stone wall or piece of timber frame-work, on which a church organ is placed, and which in English cathedrals and churches forms usually the western termination of the choir

Organum, a name given to a machine or contrivance in aid of the exercise of human labour in architecture and other arts

Oriel window, a projecting angular window, mostly of a triagonal or pentagonal form, and divided by mullions and transoms into different bays and other proportions. The word *oriel* has been discussed by many writers, but there cannot be conceived an architectural charm more cheerful to the interior, or more decorative to the exterior of a building, than an oriel window.

Orlop, in shipping, the middle deck

Ornithon, an aviary or poultry-house, or the appurtenance to a farm villa

Orrery, in mechanics, a machine which by many complicated movements represents the revolutions of the heavenly bodies

Orthography, in architecture, the elevation of a building, showing all the parts thereof in their true proportions: the orthography is either external or internal. The external is the delineation of the outer face or front of a building; the internal is a section of the same.

Oscillating Engine, a marine engine,

with a vibrating cylinder, having the piston-rod connected to the crank, and the cylinder supported by the trunnions projecting from the sides at or near the centre, cast hollow and connected to the steam and eduction pipes

Oscillation, or vibration, in mechanics, the act of moving backward and forward like a pendulum

Oscillation, the axis of, in mechanics, a right line parallel to the apparent horizontal one, and passing through the centre, about which the pendulum oscillates

Osterly House. "The opulence and gallantry of Sir Thomas Gresham rivalled the wonders of romance. Queen Elizabeth had visited that superb mansion, and on quitting the window to seek her bed, had remarked aloud, 'How much more gracefully the court yard would appear if divided in two by a wall.' The words were caught up by Sir Thomas, who instantly, on quitting the royal presence, sent hastily to his masons and bricklayers, assisted them with innumerable labourers, worked all the night, and completed the wall according to the Queen's wishes before she had risen from her bed. The courtiers were chagrined at the knight's abruptness, and one of them consoled himself with a conceit, 'that it was no way strange that one who could build a *'change* could *exchange* a building.'"

Ostium, an inner door, the door of a chamber

Outward angle, the same as a salient angle

Ova, in architecture, ornaments in the form of eggs, carved on the contour of the ovolo, or quarter-round, and separated from each other by anchors and arrow-heads

Oval, a figure in geometry, bounded by a curve-line returning to itself.

Overshot-wheel, a wheel driven by the weight of water conveyed into buckets, disposed on its circumference so that one part of the wheel is loaded with water while the other is empty

Over story, the clear story or upper story of a building

Ovolo, a convex moulding, mostly used in classical architecture; in the Roman examples it is an exact quarter of a circle; in Grecian it is more flat and quirked at the top. It is frequently used in the decorated Gothic style.

Oxidation, rusting; the process of converting metals and other substances into oxides, by combining a certain portion of oxygen with them

Oxygen, in chemistry, a gaseous element, of great importance in the economy of Nature: it is essential to the maintenance of organic life: hence its original name, 'vital air.'

PAC

PACK, a quantity of material, either wood or coals, placed or piled up to support roofs, or for other purposes

Paddle-shaft, the shaft upon which the paddle-wheel is fixed, placed centrally with, and connected to, the crank-shaft

Paddle-wheel, the wheel fixed upon the paddle-shaft, for propelling a vessel through the water by the action of a number of paddle-boards fixed at the circumference

PAG

Pagoda, in architecture, a name applied by the Europeans to Hindoo temples and places of worship, but not by the Hindoos themselves, who have no such appellation; they are square stone buildings, not very lofty, crowned with a cupola: the pagodas of China are, however, lofty houses, which sometimes rise to the height of nine stories, of more than twenty feet each. The buildings are depositories of the idols, and used for their worship

Painted and *Stained Glass*, formerly used exclusively for ecclesiastical purposes, — displaying devotion and spiritual bearing. Latterly painted and stained glass have been used for domestic purposes. The art of painting on glass was known as early as the sixth century, and was applied to the enrichment of the basilica of St. Sophia, and other churches in Constantinople; and in the reign of Charlemagne some progress was made in enriching and beautifying glass with colours. In the tenth century it was much admired, and advanced rapidly: Henry II. patronized this art. In France it progressed in all the magnificence of colour and execution, and was extensively diffused in England. In Canterbury and York some beautiful examples remain, for the admiration and example of modern practice. Of the unique cento style, the revival of art under the immortal Albert Durer, some very fine specimens of the period, picturesquely drawn, are to be found in fine preservation in St. Jacques, at Liége; and of rather a later time, those of the Crabeths, at Gouda, in Holland, are magnificent executions of this art by these brothers. One of these windows, upwards of 70 feet high, was executed by Theodore Crabeth, by command and at the expense of Queen Mary of England, consort of Philip II.: a portion of the picture is magnificently painted, the subject of which is the Queen, with her husband, kneeling at the Lord's table. The upper part of this window has been destroyed by a storm, but the subject referred to remains perfect, and exhibits correct likenesses of these sovereigns.—(See 'Divers Works of Early Masters,' in 2 vols.)

Painting. The art of painting gives the most direct and expressive representation of objects; and it was doubtless for this reason employed by many nations, before the art of writing was invented, to communicate their thoughts, and to convey intelligence to distant places. The pencil may be said to write a universal language, for every one can instantly understand the meaning of a painter, provided he be faithful to the rules of his art: his skill enables him to display the various scenes of nature at one view, and by his delineations of the striking effects of passion, he instantaneously affects the soul of the spectator. Invention in painting consists principally in three things: first, the choice of a subject properly within the scope of the art; secondly, the seizure of the most striking and energetic moment of time for representation; and, lastly, the discovery and selection of such objects, and such probable incidental circumstances, as, combined together, may best tend to develop the story or augment the interest of the piece.

Architects will often find decorations of a room and its furniture well worthy of their study. In houses recently built, both in town and country, the taste of the architect has been called in, to give designs for the arrangement of curtains, for grates, pier tables, chairs, and sofas; and in many instances the superior chasteness of the designs, and the harmony of the whole with the architectural style of the rooms, may be seen, conformable with the different uses to which the rooms are appropriated.

Painter, in navigation, a sea term for a rope employed to fasten a boat to the ship, wharf, &c.

Palæstra, a building appropriated to gymnastic sports

Palaces of Persia (the royal country) are at this day castellated, and many villages have towers of defence

Pale, in heraldry, the third and middle part of the escutcheon

Palisander, a name used on the continent for rose-wood

Pall, in heraldry, denotes a sort of cross, representing the pallium or archiepiscopal ornament sent from Rome to metropolitans

Palls, in ship-building, strong short pieces of iron or wood, placed near the capstan or windlass, so as to prevent their recoiling

Palladium, a metal found with platina, but in small quantity

Palladium, in antiquity, a wooden image of the goddess Minerva or Pallas, the possession of which involved the fate of Troy

Pallium or *Pall*, in church rituals, a pontifical ornament worn by popes, patriarchs, primates, and metropolitans of the Roman church, in the form of a fillet of black silk, over the shoulders, with four red crosses

Palm-trees, wood of great variety, imported from the East and West Indies, but sparingly employed in England for cabinet and marquetry work, and sometimes for billiard-cues, &c.

Palette (French), in painting, a light board on which the colours are held

Palsgrave, in heraldry, a count or earl, who has the overseeing of a palace

Pane, the light of a window; formerly applied also to the sides of a tower, turret, spire, &c.

Panel, in carpentry, &c., a square piece of any matter inserted between other bodies; sunken compartments of wainscoting, ceilings, &c., principally employed in Gothic and Domestic architecture for interior fittings

Panel, a space or compartment in a wall, generally of English or Flemish oak, and on a ceiling, enclosed within a raised margin

Panel, in mining, a heap of ore dressed and ready for sale

Panemore, in mechanics, a globular wind-mill, proposed to be erected in the centre of a ship, for turning wheels and paddles.

Panoply, in heraldry, complete armour

Panorama (Full view), in painting, a picture drawn on the interior surface of a large cylinder, representing the objects that can be seen from one station when the observer directs his eye successively to every point of the horizon

Pantheon, a temple dedicated to all the gods; one of the most celebrated edifices of Rome

Pantograph, in mechanics, an instrument contrived for the purpose of copying drawings, so that the copy may be either similar to or larger or smaller than the original. (See *Pentagraph*.)

Para, in Cornish mining, a gang or party of men

Parabola, one of the conic sections formed by the intersection of a plane and a cone when the plane passes parallel to the side of the cone

Parabolic Pyramidoid, a solid generated by supposing all the squares of the ordinates applicable to the parabola so placed that the axis shall pass through all their centres at right angles, in which case the aggregate of the planes will form the solid called the parabolic pyramidoid, the solidity of which is equal to the product of the bases and half the altitude

Paraboloid or *Parabolic Conoid*, the solid generated by the rotation of parabola about its axis, which remains fixed. A frustrum of a paraboloid is the lower solid formed by a plane passing parallel to the base of a paraboloid.

Parabolic spindle, the solid generated by the rotation of a parabolæ about any double ordinate

Paradise, a private apartment, a study, the private appurtenances to a convent

Paradromides, hypæthral walks, attached to the Greek palæstra. The Romans called these walls xysta; whereas the xysta of the Greeks were covered porticoes, in which the athletæ exercised in winter

Parallel, in geometry, is applied to lines, figures, and bodies which are every where equidistant from each

other, or which, if ever so far produced, would never meet

Parallel bars, the rods parallel to the centre line of a beam, joining the connecting links at the lower ends.

Parallel motion, the connection between the top of the piston-rod and the beams: a name given to a contrivance, invented by James Watt, for converting a reciprocating circular motion into an alternating rectilinear motion

Parallel ruler, an instrument consisting of two wooden, brass, or steel rulers, equally broad throughout, and so joined together by the cross blades as to open to different intervals, and accede and recede, yet still retaining their parallelism

Parallelogram, in geometry, a quadrilateral right-lined figure whose opposite sides are parallel

Parallelogram of forces is a phrase denoting the composition of forces, or the finding a single force that shall be equivalent to two or more given forces when acting in given directions

Parallelopiped, in geometry, a regular solid, contained under six parallelograms, the opposite of which are equal and parallel; or it is a prism whose base is a parallelogram: it is always triple to a pyramid of the same base and height

Parament, the furniture, ornaments, and hangings of an apartment for a room of state

Parameter, a constant right line in each of the three conic sections, and otherwise called *latus rectum*, because it measures the conjugate axes by the same ratio which has taken place between the axes themselves, being always a third proportion of them

Parapet, the upper part of a house, which is above the springing of a roof, and guards the gutter; the upper part of a wall, a bridge, a terrace, or balcony, &c. Parapets around the flat roofs of houses in the East are of the most ancient *date*. "When thou buildest a new house, then thou shalt make a battlement for thy roof, that thou bring not blood upon thine house, if any man fall from thence.—*Deut.* xxii. 8.

Parascenium, in ancient theatres, a place behind the scenes to which the actors withdrew to dress and undress themselves

Parastalæ, square columns, or antæ; called also parastacles and parastalicæ. Vitruvius uses the term to signify the square posts placed behind the columns of the basilica, for the support of the floors of the upper porticoes

Pargeting, parge-work, plaster-work, employed exteriorly for timber houses, as an ornament; used also in plain and ornamental work, for both the exterior and interior

Paries, the walls of a Grecian house, in contradistinction to the wall of a city; a small enclosure, such as a court yard

Parlour, a private apartment in a dwelling, usually on the ground floor; a speaking-room in a convent. In the time of Henry VIII. parlours and privy rooms—summer parlours, winter parlours — were well, comfortably, and conveniently furnished; a proof that the gentry of that period were not quite so far behind the present race as might be supposed.

Parsonage-house, a residence of the incumbent of a parish, a building in the vicinity of a church

Patera, a round dish, plate, saucer, or goblet

Patina, a basin or bowl of earthenware, rarely of bronze

Parthenon, in architecture, the temple of Minerva at Athens

Particle, the minute part of a body, or an assemblage of several atoms of which natural bodies are composed

Partners, in naval architecture, are thick pieces fitted into a rabbet in the mast carlings, to receive the wedges of the mast; likewise temporary pieces nailed on the deck round the pumps

Partridge wood is the produce of the

Brazils and the West India Islands: it is sent in large planks, or in round and square logs. It was formerly employed in the Brazils for ship-building, and is known in dockyards as cabbage-wood.

Party-walls are partitions of brick made between buildings in separate occupations, for preventing the spread of fire. These are made thicker than the external walls; and their thickness, and the necessity of their use, are regulated by Act of Parliament, and specified in some of the clauses of the Buildings Act passed in the reign of the present Queen.

Parvise, a porch; an open area before the entrance of a church

Paschal, a stand or candlestick, of a large size, used in Roman Catholic worship

Pasigraphy, the art of universal writing

Passant, in heraldry, a term applied to an animal in a shield appearing to walk leisurely: for most beasts, except lions, the word *tripping* is frequently used instead of *passant*

Passion, in painting, implies an emotion of the body, attended with certain expressive lines in the face, denoting an agitation of soul

Pastici, or *Imitations in Paintings*. Teniers understood the union of colours extremely well, yet Bassan was superior to him in the sweetness and vigour of his tints. De Pile recommends it to all persons who would not wish to be deceived by pastici, to compare the taste of design, the colouring and the character of the pencil, with the originals. Teniers, Giordano, and Bon Boulloque are those who have appeared with the greatest reputation for imitating other great masters; and, beside these, many other artists have employed themselves in painting pastici.

Pastoral staff, the official staff of an archbishop, a bishop, or mitred abbot

Patand, the bottom plate or sill of a partition of a screen

Paten, a small plate or salver used in the celebration of the eucharist

Patents for Inventions are public grants to the inventors of new and useful machinery and processes in the arts, and by which certain privileges are secured to the inventors, for the exclusive use and exercise of their inventions during a limited period. Patents are therefore monopolies of a definite character; but being designed as a security for the reward of those whose ingenious faculties and practical skill have produced inprovements of general utility and value, these monopolies, if justly granted and honestly exercised, are not to be decried as injurious to the public interests, but should be conceded with willingness, and command the liberal protection of the community, which is destined to reap a continual and permanent advantage from the improvements thus fostered in their infant development. Patents for inventions should therefore be admitted as bargains between the inventor on the one hand, and the public on the other; and the abuses to which these bargains are liable arise from the common causes of official corruption and individual cupidity and jealousy.

The laws under which patents are granted vary in their form in the several European and American States, and are all, in some degree, imperfect, and ineffective of their proper object.

In Great Britain and Ireland, *Letters Patent* (founded on statutes from the 18th of Henry VI., but mainly on the 21st of James I. c. 3) are granted by the Crown, on behalf of the public, to the inventor of any manner of new manufacture, for the sole privilege to make, use, exercise, and vend his said invention, during the term of fourteen years; and an inventor, as thus

privileged, may be the first *inventor* absolutely, the first *publisher* if others have also made the same invention, or the first *importer* from abroad, into these realms, of an invention not previously herein used and exercised. British patents are granted as matters of course, provided certain legal forms are duly complied with, certain official fees (which are very high) are duly paid, and the legal advisers of the Crown (the Attorney or Solicitor General) are not required by opposing parties to discover that the privilege sought will interfere with any contemporary application.

The several processes in soliciting a British patent are as follow: The inventor has to petition the Crown to grant letters patent for his invention, of which, at this stage, he states only the title; and he accompanies his petition with a declaration of the grounds of his request, and the provinces in which he wishes to secure his patent right. These documents are lodged at the office of the Secretary of State for the Home Department, whence they are referred to the Attorney or Solicitor General,—the selection of either of these officers being with the inventor. If no opposition occur therefrom *caveats*, (which are formal notices that any one may enter, to be informed of applications for patents,) one of those officers makes a report on the petition, and recommends that letters patent be granted thereon, provided the petitioner enrol the necessary specification, &c. within the time limited by the statute. This report is taken to the Secretary of State's office, for the Royal warrant, directing the bill to be prepared for the Royal signature. The warrant is committed to the Attorney-General, and if not opposed, he prepares the bill, which is signed at the Secretary of State's office. Under Royal warrant, sealed with the Royal signet, the bill receives the privy seal, and i directed to the Lord Chance letters patent to be made o sealed with the great seal. this practice, that of sol patents for Scotland and I differs only in minor detai common feature of the a ment being that of a mult alike of forms and fees, whi hance the trouble and e without promoting the efi or security of the system.

Having obtained the gre the patentee is allowed a pe six months to complete his ments, and to have his sp tion (and drawings, if req prepared. For this purpos care and judgment are r based on a knowledge of patents, to frame the speci so that it shall explain wit cient clearness the precise of the improvements, an that value as property, w good specification of a always has. On or before t day of the allotted six mont specification must be duly e and the patentee receives an certificate of its enrolment patent is now *complete*, a patentee can safely proc practise under it.

By a comparatively recent (5 and 6 William IV. c. patentee is now enabled, un authority of the Attorney licitor General, to amend b and specification subsequer necessary, to correct one, t it consistent with the other, fact, to disclaim part or part claims, which he may hav found to be untenable. Un same statute also, the invent petition for a prolongation term of fourteen years; petition is referred to the J Committee of the Privy C who grant the same if the pe makes out a case, satisfac them, of extraordinary los

lays, or other special reasons for the prolongation.

The *property* in a patent can be defended from infringement by a bill in equity, or action at law. It may be assigned, in whole or part, by the patentee to any number not exceeding twelve persons. It may be mortgaged to any number of persons; and a patentee can also grant licences for the use of his patent, in a variety of modes, to an unlimited number of persons.

The *cost* of obtaining a patent, including fees for agency, if unopposed, is for England, £110; for Scotland, £80; and for Ireland, £135. If the patent be granted to two or more persons jointly, which it may be, extra fees are charged for the additional names; and if the Channel Islands of Guernsey, Jersey, Alderney, Sark, and Man, and the British Colonies and Plantations abroad, are included, a further expense of about seven guineas is incurred. To these items should be also added the cost of preparing and copying specification and drawings, the charges for which are of course very variable, according to length, intricacy, &c.

The expenses and regulations under which the foreign patents are granted vary considerably. The following brief epitome must suffice in this place.

In the United States of America, patents are granted only to the absolute inventor, always for fourteen years, and are granted or withheld at the option of the Government Commissioners of Patents. The amount of official fees payable *depends upon the country of which the applicant is a native.* Thus, a citizen of the United States, or a foreigner who has resided in the States one year next preceding the application, and has made oath of his intention to become a citizen, pays a fee of $30; *a subject of the Sovereign of Great Britain,* $500; *and any other foreigner,* $300. If the application for a patent be rejected by the Commissioner, two-thirds of the fees paid are returnable.

In France, patents for inventions are granted alike to natives and foreigners, and the duration of the privilege may be fixed by the patentee at five, ten, or fifteen years, the amount of tax being proportional to the term, namely, 500 francs for five years; 1000 francs for ten years; and 1500 francs for fifteen years; payable by annual instalments of 100 francs. The patentee thus enjoys the power of relinquishing his invention, if found unprofitable, at any time during the intended term, by ceasing to pay the annual instalment of fees.

In Belgium, patents are granted for five or ten years: imported inventions are patentable, and the whole of the Government tax, which is not heavy, may remain unpaid until the expiration of two years from the grant.

In Holland, patents are granted for five, ten, or fifteen years, and may be had for foreign as well as native inventions. The fees for a patent for five years are 150 guilders, or £12. 10*s.*; and for terms of ten or fifteen years they vary from 300 to 750 guilders, or from £25 to £62. 10*s.*

In Prussia, Russia, &c., the Governments exercise a discretionary power in granting or refusing patents, and the laws are of a stringent and arbitrary character.

In Austria, patents are granted for terms from five to fifteen years; the taxes must be paid when the application is made, and the invention put in practice within one year from the date of the grant.

The German and Italian States have patent laws peculiar to themselves, but generally similar to those already described.

Patent yellow, Turner's yellow, or *Montpellier yellow,* is a submuriate or chloride of lead, which metal

is the basis of the most opaque yellow pigment: it is a hard, ponderous, sparkling substance, of a crystalline texture and bright yellow colour, hardly inferior, when ground, to chromic yellow. It has an excellent body, and works well in oil or water, but is soon injured, both by the sun's light and impure air; it is therefore little used, except for the common purposes of house-painting, &c.

Patera, a circular flat ornament, used in Classical architecture; used also in Gothic and Italian architecture

Paul, the catch which holds a ratchet-wheel, allowing it to turn in one direction only

Pavilion, in architecture, a detached building; an insulated turret, contained under a single roof, sometimes square and sometimes dome-formed; named from its resemblance to the roof of a tent. The late palatial monstrosity at Brighton was called a pavilion.

Pax, a small tablet, having on it a representation of the crucifixion, or some other Christian symbol, offered to the congregation in the Romish church, to be kissed in the celebration of the mass: it was usually of silver, or other metal, with a handle at the back, but was occasionally of other materials; sometimes it was enamelled, and set with precious stones

Peach-stone, a blueish-green soft stone

Pearl white. There are two pigments of this denomination: one, falsely so called, prepared from bismuth, which turns black in sulphuretted hydrogen gas or any impure air, is employed as a cosmetic: the other is prepared from the waste of pearls and mother-of-pearl, is exquisitely white, and of good body in water, but of little force in oil or varnish; it combines, however, with all other colours, without injuring the most delicate, and *is itself* perfectly permanent and *innoxious*.

Pear-tree, a native European wood; its colour is a light brown, something of a pale mahogany or cedar: it is employed by the Tunbridge turners

Pea-stone, or *pisolite*, in mineralogy, pisoform limestone

Peat, in mineralogy, a substance consisting of the twigs, leaves, and roots of trees, mixed with grass, straw, plants, and weeds, that have laid long in water, and become converted into a blackish-brown mass that may be cut with a spade, and dried for fuel

Pedestal, in architecture, the lower member of a pillar, named by the Greeks stylobates and stereobates; also the basis of a statue. In Classical architecture it consists of three divisions: the base, or foot, next the ground, the dado, forming the main body, and the cornice, or sur-base moulding, at the top.

Pediment, the triangular plane or surface formed by the vertical termination of a roof consisting of two sloping sides; consequently it so far corresponds with the *gable*, but in other respects differs widely from it. One material difference between them is, that whereas the gable has no cornices, the pediment is bounded by three, viz. a horizontal one, beneath it, forming its base, and two sloping or *raking* ones, as they are technically termed; and the triangular space or surface included within them is distinguished by the name of the *tympanum* of the pediment. Another marked difference between them is, that the gable may be of any pitch; and being merely a continuation of the wall below, instead of being, like the pediment, separated from it by any horizontal mouldings, its proportions do not at all depend upon the height or width of the front or compartment of the front which it terminates, but may be an equilateral triangle, or even considerably more, as to height, and is, besides,

in nowise governed by the height of what is beneath it. The pediment, on the contrary, must be proportioned to the *height* of the order which it crowns; consequently its pitch must be decreased in somewhat the same ratio as its length or base is increased, or, in other words, the greater the number of columns beneath a pediment, the lower must the pitch of the latter be. Hence it is hardly possible to place more than eight, or, at the utmost, ten columns beneath a pediment, without making the pediment either too low in itself, or else too lofty and heavy a mass in comparison with the columns beneath it; thereby not only overloading them — the columns being proportioned to their entablature alone — but also diminishing their importance, and causing the order itself to look almost puny and meagre, while the pediment looks heavy and clumsy. There has been a good deal of mystification about determining the proportion of pediments, and special methods have been devised for that purpose, which, however ingenious in themselves, as such, are any thing but artistic, or calculated to secure pleasing proportions. Discarding all such *methods*, it may be laid down as a safe general rule, that the height of the tympanum should accord pretty nearly with that of the entablature beneath the pediment, and not greatly exceed it, under any circumstances. Such is the proportion which Wilkins appears to have observed for the pediment of the London University College; and although that building has a decastyle portico, the pediment does not appear too low, whereas that of the National Gallery is so, the height of the tympanum being there less than that of the entablature, notwithstanding that the portico is octastyle.

The ancients generally made the pediment contribute largely to the embellishment of the structure, by sculpturing its tympanum with figures in high relief, and in some instances by setting it back, and placing entire statues against it; and for such display of sculpture the pediment eminently recommends itself, both by its conspicuous situation, and by offering a far ampler surface for such purpose than any other part of the edifice; one, moreover, which not only required a higher decoration, for the sake of consistency, but an increased degree of it, in order to produce artistic climax and completion. Yet it must be confessed that if its *situation* marks out the pediment as a very proper place for making a display of decoration, its *shape* is by no means well adapted for a composition of figures, except it be that it compels them to be arranged symmetrically, and the principal one to be directly in the centre. Be the subject what it may, the figures must always be disposed in nearly the same manner, and not only very conventionally but very forcedly, particularly towards the extremities,—an inconvenience that might be easily overcome by confining the figures to the centre of the tympanum, putting there a group of three or five, and either leaving the rest of the triangular space to be quite plain, or else filling it up with mere ornament. While this would certainly be a rather less expensive mode than that now practised, and an equally rational one, its not having been adopted before ought to be itself some recommendation of it, as being a laudable infringement of copyism, conventionalism, and routine.

Besides sculpture within them, pediments are frequently surmounted at their angles and apex with *acroteria*, namely, low pedestals, upon which are placed either single figures or groups, or else vases,

trophies, or other ornaments; an example of which is furnished by Spencer House, in the Green Park, and still more strikingly by the portico of the East India House. The practice of placing statues upon pediments appears to have originated with the Romans, and is somewhat analogous in taste to that of putting them on the summit of monumental columns; for in such situations human figures show only in their general mass as sculptural accessories to the structure, and at a little distance, or as seen in a general view of the building, produce scarcely more effect than so many pinnacles, which last are infinitely more characteristic of Gothic architecture than in accordance with the character of a classical portico.

In Italian and modern architecture generally, the pediment is employed as mere decoration in compositions for the dressings of both doors and windows, which practice, like that of applying columns for the same purpose, has been condemned by some in the most unqualified manner; and one writer has vituperated, and endeavoured to bring it into disgrace, by comparing pediments over doors and windows to — cocked hats! The resemblance which he perceives, or fancies, between a cocked hat and a pediment is not a particularly flattering one; but if it exists at all, the injurious comparison holds equally good with regard to a large pediment as a small one; therefore, whether it be that over a portico or over a window, the shape itself is, in either case, the most unfortunate one of a cocked hat; yet, as cocked hats are now gone quite out of fashion, the unlucky resemblance to them is not at all likely to be detected. In matters of decoration, some latitude—some *little departure* from strict archi*tectural logic*—is allowable; other*wise a very great* deal in Italian or modern architecture must b nounced decidedly faulty. be a solecism to place ped whose form is derived from a roof, over windows, or wh roof exists, the same objecti against applying entablatures cornices resemble the hor ones of a roof, to mere open the wall; and in like mann be a gross impropriety to windows with small colun must be as great, if not a one, to introduce, merely i sake of decoration, a large whose columns are partly in the wall, and support r but an entablature, or piece wholly unnecessary in them and put there only that the c may appear to support som Again, as to the objection has sometimes been urged pediments over doors wi building, namely, those in to throw off rain, they sho introduced only in externa tions,—it partakes of the san of hypercriticism as the oth if strict *rationality* is to l formly enforced in archit design, we must condemn deal in the Gothic style a exceedingly licentious an tional; for in that we find many members and feature nating in forms invented f poses of actual service ext converted into mere inter coration; for instance, *en ments* on the tops of screens ture *buttresses* for ornament of strength, miniature *spir* miniature blank windows i mental panelling.

Pediments are generally only over the windows principal floor of a build which they serve to give tion and importance. pediments are either ang curved (i. e. segmental), a forms are frequently in together, and placed a

in which case it is usual to place an angular pediment over the centre window. Sometimes the centre window alone is, for the sake of distinction, crowned with a pediment. When, as is generally the practice, all the pediments to a series of windows are alike, they are almost invariably made angular ones, although there are instances of the contrary, one of them being Bridgewater House, where Mr. Barry has given segmental pediments to all the windows of the principal floor, and has even put them over the centre openings of the triple windows; and it deserves to be further remarked, that he has enriched their tympanums with sculptured ornament—a degree of decoration very rarely indulged in. A far more remarkable instance—perhaps an unique one—of the application of segmental pediments, may be seen in the house just erected for Mr. Hope, in Piccadilly, large pediments of that form being there placed over windows consisting of *two* openings, consequently forming square, or nearly square, instead of upright compositions; owing to which, the pediments cause them to look far more heavy than elegant. In that instance, too, the pediments are filled in with sculpture; the figures, however, are not exactly confined to the pediments, but come somewhat lower down, the horizontal cornice being partly suppressed for that purpose.

Pedometer, in mechanics, an instrument in the form of a watch, consisting of various wheels, with the teeth catching in each other, and which, by means of a string fastened to any thing in motion, numbers the paces gone over from one place to another

Peek, in navigation, a name given to the upper corners of sails extended by a *gaff, or by a yard crossing the mast obliquely, as the* mizen-yard *of a ship. The* upper extremity of those gaffs and yards is also called the peek. To 'peek the mizen' is to put the mizen-yard perpendicular to the mast.

Peek-halyards, the ropes or tackles by which the outer end of the gaff is hoisted

Peg-tankard, an ancient species of wassail-bowl, used in the time of Queen Elizabeth. It held two quarts, and had generally a row of seven pegs, dividing the height into eight equal parts, each containing half a pint.

Pendant, an ornament suspended from the roof of a Gothic or Tudor building; the hanging pendants of a vaulted ceiling, uniting solidity with ornament. The most remarkable are those in King Henry the Seventh's chapel at Westminster abbey.

Pendentive, the portion of a groined ceiling supported and bounded by the apex of the longitudinal and transverse vaults. In Gothic ceilings of this kind the ribs of the vaults descend from the apex to the impost of each pendentive, where they become united.

Pennyweight, the 20th part of an ounce

Pentagon, a figure of five angles and five sides: when these are equal, it is called a *regular* pentagon, but otherwise, it is *irregular*

Pentagraph, an instrument whereby designs, prints, &c. may be copied, in any proportion, without a person being skilled in drawing. (See *Pantograph*.)

Pentangular, in geometry, five-cornered or angled

Pentastyle, in architecture, a work in which there are five rows of columns

Pentelic marble, in statuary, a beautiful and glossy variety of Parian and Carrara marble, named from Mount Pentelicus, near Athens, where it was quarried. Pentelic marble, from the smallness of the grain, is mistaken for the Parian but, of the two, the former is c

finer quality. The Pentelic quarries display in a remarkable manner the energies of the ancient Athenians: whole sides of the mountain have disappeared, and present uniformly cut perpendicular cliffs; and holes, still to be traced on the slope of the quarries, made for the insertion of capstans, mark the place of the mechanical descent of the marble; whilst a damaged and rejected cylinder, apparently intended for a part of a column of the Parthenon, interests the traveller on the ascent.

Penthouse, a projection over a door, an entrance, a window, or a flight of steps, &c., for protection from weather

Peperino marble, in mineralogy, a calcareous stone, something of the nature of travertino. It is supposed to be the ancient *Saxum Albanum*, of which the foundations of the capitol at Rome (still to be seen) were built.

Perambulator, in surveying, an instrument for measuring distances; named also the *Pedometer* and *Surveying wheel*

Perch, a small projecting beam, corbel, or bracket, near the altar of a church

Perch, or *Pole*, a linear measure of 5½ yards

Perclose, an enclosure, a railing; sometimes used to protect a tomb, or to separate a chapel from the main body of the church

Percussion, in mechanics, the striking of one body against another, or the shock arising from the collision of two bodies

Periacti, the revolving scenes of the theatre, called *scenæ versatilis* by the Romans: they were placed before the *itinera versurarum*, or those entrances to the stage which were in the returns of the permanent scene

Periactos, a theatrical machine, consisting of three scenes placed in the form of a triangle on a revolving platform; so that, by simply turning the machine, the scene could be changed

Pericles, at Athens, executed the famous statue of Minerva, of gold and ivory. Pausanias says, it was standing erect, her garments reaching to her feet; she had a helmet on, and a Medusa's head; in one hand she held a spear, and on the other stood a Victory, of 4 cubits high. Pliny tells us the statue was 26 cubits high (37 ft. 8 in.), in which he perhaps included the pedestal, whereon they both say the birth of Pandora was represented. We are not told whether the ivory was painted; but by what Strabo says, that Panænus, the brother or nephew of Phidias, assisted him in colouring the statue of Jupiter at Elis, which was likewise of ivory and gold, it probably was. The reason why ivory was used in statues of this kind, rather than wood, seems not to have been on account of its colour, but because wood is apt to crack, and to be destroyed by worms: but ivory is not of uniform colour, being yellow near the outside of the tooth, and white in the middle; it therefore would require painting on that account, and likewise to hide the joining of the pieces. Thucydides says the gold about it weighed 40 talents, which, according to the value of gold at that time, was worth about £120,000 sterling.

Peridromus, in ancient architecture, the space of an aisle in a peripteron, between the columns and the wall, used for walks by the Greeks

Perimeter, the boundary of any figure, being the sum of all the sides in right-lined figures, the same as circumference or periphery in those of a circular form

Periphery, the circumference of a circle or ellipse

Peripteral, a temple which had its cella surrounded by columns

Peristylium, a continued row or series of rows of columns all round a court or building, in contradistinc-

tion to porticoes, in which the pillars did not surround a space, but were arranged in one or more parallel lines

Peritrochium, in mechanics, a wheel or circle concentric with the base of a cylinder, and moveable together with it about an axis: the axis, with the wheel and levers fixed in it, to move it, constitute that mechanical power called *axis in peritrochio*

Perpendicular, in geometry, a line crossing or cutting the horizon, or another line, at right angles

Perpendicular, formed of one line meeting another, so as to make the angles on each side of it equal to each other

Perpendicular Style of Gothic Architecture, derived from the Decorative about the end of the fourteenth century, and continued till the middle of the sixteenth: it is so called from its tracery consisting of perpendicular lines, and forming one of its most striking features. Many fine examples yet exist in England. The perpendicular character of the style is exhibited in the window tracery, where the transoms cross the mullions at right angles; and in large windows these are occasionally repeated several times: bands, quatrefoils, and other ornaments are more frequently employed than in the other styles, and are often carried across the panellings and vertical lines, creating a rectilinear arrangement, pervading most of the subordinate parts, that gives a peculiar air and stiffness. Panelling is used most abundantly on walls, both internally and externally, and also on vaulting. Some fine examples of this style are drawn in Mr. Parker's 'Glossary,' in 2 vols.

Perpent-stone, a bond-stone; a large stone reaching through a wall so that it appears on both sides of it

Perpetual motion is that which possesses within itself the principle of motion

Perron, in architecture, a staircase outside of a building, or the steps in front of a building leading up to the first story

Persian Wheel, a name given to a machine for raising water, which may be turned by means of a stream acting on and turning round the wheel. The buckets, instead of being firmly fastened, are hung upon the wheel by strong pins, fixed in the side of the rim, which must be made as high as the water is intended to be raised above the level of that part of the stream in which the wheel is placed.

Persians, in ancient architecture, male figures employed to support entablatures; the female figures were named *Caryatides*

Perspective, in painting, &c., the science by which all things are ranged on a plane surface, as in a picture, according to their appearance in their real situation

Pew, an enclosed seat in a church, introduced since the Reformation. Previous to the Reformation the nave was occupied by the congregation. Pews are fixed seats, separated from each other by wainscoting, and varying in height.

Pewter, in metallurgy, a mixed metal, consisting of tin variously alloyed with lead, zinc, bismuth, or antimony. Common low-priced pewter contains 20 parts tin, 3 lead, 1 brass; best pewter, 17 parts antimony, 100 parts tin, and a little copper. Pewter dishes and wooden trenchers were the ordinary services of our ancestors till the time of Elizabeth, when "by reason of sharpe laws provided in that behalf," pewter was compounded of purer metal than before. The splendid services of gold and silver were only used on occasions of ceremony and on festivals.

Pharos or *Pharus*, a lighthouse. The most celebrated lighthouse of antiquity was that situated at the entrance of the port of Alexandria

built by Sostratus on an island, by the direction of Ptolemy, at a cost of 800 talents. Pliny mentions the lighthouses of Ostia and Ravenna. The name of Pharos was given in allusion to that of Alexandria, which was the model for their construction.

Phidias, the great Greek sculptor and director of the works under Pericles

Phonics, the doctrine of sounds, otherwise named acoustics

Phosphate of iron is a native ochre, which classes in colour with the deeper hues of ultramarine ashes, and is eligible for all their uses. (See *Blue ochre*.) Slate-clays and several native earths class with grays; but the colours of some of the latter, which have been tried, are not durable, being subject to become brown by the oxidation of the iron they contain.

Physics, the doctrine of natural bodies, their phenomena, causes, and effects, with their various motions, operations, affections, &c. Taken in its most enlarged sense, it comprehends the whole study of Nature, and includes physiology and natural history.

Piazza, an open area or square; a covered walk or portico

Pick, an instrument in common use as well in agricultural as in mining operations

Pictura (Latin), a painting. The art of imitating the appearances of bodies upon an even surface, by means of light and shade, or colour, was most extensively cultivated by the ancients, but especially by the Greeks, amongst whom it was carried to the highest degree of technical development.

Pier, in architecture, the strong columns on which the arch of a bridge is raised

Pier, the solid mass between doors, windows, and other openings in buildings: the term is often applied to pillars in Norman and Gothic architecture

Piers, walls built to support arches, and from which, as bases, they spring

Pilæ, square blocks placed upon the epistylia, and immediately over the columns in a basilica, for supporting the timbers of the roof. Pilæ were also buttresses built against the walls of a mole, to resist the force of the waters.

Pilaster, in architecture, a square column, sometimes insulated, but more frequently set within a wall, and only showing a fourth or fifth part of the thickness. Pilasters were unknown in Greek architecture, in which only antæ (see *Antæ*) were admitted: they are employed by the moderns as substitutes for an order in engaged columns, and are, perhaps, even preferable to the latter, inasmuch as they combine better and more naturally with the wall to which they are attached.

Piles, as applied in engineering operations, are used both in temporary and in permanent constructions. In the former cases, they are commonly squared logs or baulks of timber, which are driven close together in single or double rows, so as to enclose a space of water, and form a coffer-dam, from which the water is subsequently pumped out, and thus a dry space obtained for laying the foundations of piers, abutments, &c. in bridges and other similar works. The most substantial kind of coffer-dam, adapted for works which will be long in construction, is formed of a double row of concentric piling, a space of 3 or more feet being left between the two rows of piles, which is filled with clay, well puddled or rammed in. For permanent works, piles are driven in loose or uncertain strata in rows, leaving a space a few feet in width between them, and upon the heads of the piles the foundations of the superstructure are erected. In some of the iron bridges lately erected for railways,

piles have been used as substitutes for solid piers in the water. Wharf-walls have also been built with facings formed with piles. In most of these works the piles used are of cast iron, while those used for coffer-dams and foundations are of timber, the lower end being fitted with a wrought-iron pointed shoe, to facilitate the penetration of the strata, and the head of the pile guarded with a ring of the same metal, to prevent its splitting while being driven. Iron piles are cast in various forms; sometimes so as to preserve similar external dimensions to timber piles, and hollow or tubular within; and if for wharf-walls, they are formed with grooves in the sides, into which metal plates are fitted, the piles being placed from 4 to 7 feet apart, and the intermediate spaces filled up with these plates.

For piling in loose and moveable materials, and more especially for forming moorings, Mr. Mitchell has introduced a form of pile which is properly called a *screw-pile*, the lower end being formed as a screw, and fitted (for moorings) with a broad plate or disc of metal in a spiral or helical form. The most important purpose to which the screw-pile has been applied is for forming the foundations of light-houses, beacons, jetties, &c., in places where the sand or soil is too unstable to bear the weight of any massive structure, or where the force of the waves would endanger masses of masonry by undermining the materials below them. The lighthouse erected in the year 1840 upon the Maplin Sands may be instanced as a work which owes the very possibility of its existence to these screw-pile foundations. The piles used in this structure are nine in number, and made of malleable iron, 5 inches in diameter and 26 feet long, with a cast-iron screw *4 feet in diameter*, screwed to the *foot of each. Eight* of the piles were placed at the angles of an octagon, and the ninth in the centre, and were put down in nine consecutive days, being screwed to a depth of 22 feet in the bank. Several similar works have been since constructed with complete success; and in 1847, the screw-piles were applied in the construction of a jetty 260 feet in length beyond the old one, at Courtown, on the coast of Wexford. Malleable-iron piles, 5 inches in diameter, and laid in the ground 11 to 15 feet, were fitted with screws 2 feet in diameter. The facility and rapidity with which these piles are inserted are not the least among their qualifications.

Before the introduction of screw-piles,— the process of fixing which consists in giving them a rotatory motion by means of capstans,—the fixing of piles was accomplished by driving them downwards by the force of an adequate weight, which was permitted to fall vertically on them from a considerable height. The machinery employed was therefore properly called a *pile-driver*, and consisted simply of a vertical framing, provided with winches and chains, by which the weight or 'monkey' was alternately raised by manual power, and released so as to fall upon the head of the pile; or a gin was applied, and horses used for the same purpose.

Within the last few years a great improvement has been effected in the machinery for pile-driving, by the application of steam power. The earliest invention for this purpose is recorded in a patent granted in 1806, but no practical application appears to have resulted for many years. The patent referred to was dated June 6, 1806, and granted to William Deverell, for "improvements in the mode of giving motion to hammers, stampers, knives, shears, and other things, without the application of wheels, pinions, or any rotative motion,

means of various powers now in common use." The apparatus was designed to consist of a steam-cylinder with piston and rod, and a hammer, raised by admitting the steam below the piston. By the condensation or the escape of the steam, the hammer and the piston were allowed to descend, urged both by their own weight and by the elasticity of the compressed air in the top of the cylinder above the piston. This, therefore, established the *principle* of the steam-hammer; but the most successful application of it to the purposes of driving piles, as well as to those of the smithery, is due to Mr. James Nasmyth, whose steam-hammer consists of a steam-cylinder, which is closed at the bottom, but has openings in the top, to admit the passage of air. The rod of the piston passes through a steam-tight aperture in the bottom of the cylinder, and has the 'monkey,' or driver, weighing 2½ tons, suspended from it. The machine is worked with high-pressure steam, which, entering the bottom of the cylinder, raises the piston and 'monkey.' When the piston reaches the height intended, it shuts the induction and opens the eduction pipe (also at the bottom of the cylinder), by which the steam escapes, and the monkey falls. A heavy iron cap slides between standards and round the head of the pile, and thus guides it in its descent. This machine, as used at Devonport, in driving piles for the steam-dock, made seventy strokes per minute, and drove piles 14 inches square and 18 feet in length.

In the year 1843 (December 5), a patent was obtained by Dr. L. H. Potts, for "improvements in the construction of piers, embankments, breakwaters, and other similar *structures*." The several objects comprised in this invention were sought with considerable ingenuity, and have been realized with success. The invention includes the application of hollow piles of iron, of a cylindrical or other convenient form, and sinking them by withdrawing the sand, &c. within them by the action of an air-pump. For this purpose the pile is fitted with an air-tight lid, through which a pipe passes to connect the interior of the pile with a receiver. The receiver is connected by a pipe with a three-barrelled air-pump, by working which the air is exhausted from the hollow pile, and the sand and water raised into the receiver, which is emptied as often as necessary. A second purpose proposed in this patent is the use of skeleton frames or cases of cast iron in connection with the piles, for securing them together, and preserving their relative positions. A third object is the injection, by hydraulic pressure, of such chemical solutions about the feet of the piles as will consolidate the sand upon which they stand, and thus secure the work. And the inventor also proposed to use hydraulic cements in a dry state, delivered at the base of the piles, by the admixture of which cements with the water they would become solidified, and thus materially aid in strengthening the superstructure.

Recently these piles have been successfully used on the Goodwin Sands, by the Trinity Board. Previously, engineers had been baffled in finding a bottom. The piles have now been fairly affixed to the hard bottom, seventy-five feet through the sand.

In connection with Mitchell's, Nasmyth's, and Potts' modes of piling, it is proper to notice also Cram's patent pile-driving locomotive machine, which was successful in its operation in the United States. The volume ('Ensamples of Railway-Making') from which the following extract has been made was edited by the publisher of this Dictionary, with a view to induce a

cheaper mode of construction of railways in countries less wealthy than those already intersected by iron roads:

Pile-road.—As a considerable length of the Utica and Syracuse railroad passes through a deep swamp, a foundation of great permanency was required: this gave rise to a modification of the superstructure, and formed that which is known as pile-road. The swamp varied in depth from 10 feet to 60 feet, and was nearly on a dead level throughout: the grade-line closely corresponded with its surface; so that it was necessary to reach the hard bottom before *any* foundation could be effected. Piles were adopted as the cheapest and most efficacious means to secure a durable and substantial basis: they were driven to their places by a steam pile-driver. This was a machine formed of a platform about 25 feet long and 8 feet broad: at one end were erected two pairs of leaders or guides, in which the hammers moved. Immediately behind the leaders were fixed the rollers, with the necessary brakes and gearing for working the hammers, raising the piles, &c. The rollers were revolved by a small high-pressure steam engine, occupying the rear of the machine. The arrangement of the leaders was the same as in ordinary piling machines: a curved piece of wood forced open the sheers when the hammers reached their elevation. The hammers were confined to the leaders by a groove: they weighed about 1000 lbs. each, were made of cast iron, and at their last blow fell through a space of 27 feet. A pair of piles were driven at one operation by this machine; when driven, cast-iron rollers were placed upon their heads, and the machine, by means of an inverted rail, moved on to the next place. The heads *of the piles, sawed off to reduce them to the proper level,* were found sufficient to supply the furnace with fuel.

The men employed in operating the machine were,—a foreman, a steam engineer, two brake-men, and two men in front at the saws; also a horse and cart, to furnish water for the boiler. Properly geared in front of the machine, and between the leaders, was a saw that played on a sway-bar and could be pressed against either pile as it was driven home. The machine was manufactured complete for the cost of £400.

Each pile was prepared for being driven by simply sharpening one end to a point, and squarely butting the other; it was drawn up by ropes worked by the engine, secured in position between the leaders, and driven to the hard bottom. Generally the piles manifested no disposition to split: when they did, their heads were encompassed with an iron hoop. When the pile was not of sufficient length to reach the hard bottom, another was dowelled upon its head, and this was repeated as often as necessary. The piles were charred, to increase their durability; and an auger-hole, bored in their heads for the purpose, was filled with salt, and securely plugged up.

Pillar, a kind of irregular column, round and insulate, but deviating from the proportion of a just column. The term pillar is more usually applied to Gothic architecture than to the Classical, the latter being governed by the rules of proportion: not so with the Gothic pillar, it being subject to no fixed rules.

Pillars (*monumental*), columns raised for the commemoration of events, a practice from remote antiquity. "Jacob set a pillar upon her grave: that is the pillar of Rachel's grave unto this day." (*Gen.* xxxv. 20.)

Pillars, in ship-building, pieces fixed under the middle of the beams, to support the decks

Pillion, the tin that remains in the slags after it is first melted.

Pinacotheca, a picture gallery. The public gallery at Munich is called the *Pinakothek*.

Pindrill, a drill used for cutting a recess for a bolt-head, or for enlarging a hole

Pines and *Firs* are cone-bearing timber-trees which thrive best in cold climates: they are of great variety, and the general uses of the wood are innumerable, besides those for ships and house carpentry. Its use in England is most extensive: it is principally imported from America, Norway, the Baltic, Memel, Riga, Dantzic, &c.

Pinion, in mechanics, an arbour or spindle, in the body of which are several notches, into which the teeth of a wheel catch, that serves to turn it round; it is also the name of a lesser wheel that plays in the teeth of a larger one

Pinite, a micaceous mineral

Pink, in navigation, a name given to a ship with a very narrow stern

Pinnacle, an ornament placed on the top of a buttress as a termination to an angle or gable of a house, church, or tower; also a summit or lofty apex

Pins, in ships, are fixed in the drum-heads of capstans, through the ends of the bars, to prevent their unshipping; sometimes put through the bolts to belay a rope, and called belaying pins; and sometimes the main bolts are called bolt-pins

Pipe, a tube for the conveyance of water, gas, or steam, of various dimensions and uses

Pipe, in mining, a running vein, having a rock root and sole

Piscina. Pliny says the Romans adorned the walls, ceilings, and floors of their baths. It was on the piscina they bestowed the most art. In the baptisterium they dipped their whole body, and this was large enough to swim in; but when they were disposed to swim at large in warmer water, they entered the piscina, a basin so called, as its size bore some resemblance to a pond. When the thermæ were built, they were made to contain lakes of warm water: the water acquired its heat by passing through the fire in a brass pipe, and must have been more or less hot according to the length of its progress.

Piscina, a shallow stone basin, or trough, with a hole in the bottom, formerly placed near to the altar in Roman Catholic churches, and fixed at a convenient height above the floor, to hold the water in which the priest washed his hands; also for rinsing the chalice at the time of the celebration of the mass. It was usually on the right-hand side, on the approach to the altar.

Pisé, a peculiar mode of forming buildings, particularly those for cottages and farming purposes, with some sort of stiff earthy materials of a loamy quality. The earth so collected, framed, is well rammed until the moisture is driven out, and used to make the walls or sides of the building, instead of bricks. It has been used with much economy and success on the Continent, and in some parts of England.

Pistici, or *Pastici*, a term by which Italians distinguish pictures which cannot be called either original or copies, being the works of some artists who have had the skill to imitate the manner of design and colouring of other eminent masters; sometimes borrowing part of their pictures, sometimes imitating their touch, their style of invention, their colouring, and expression. Several painters, of considerable reputation for their own original performance, have made themselves remarkable in this way; but none of them more than David Teniers, who so successfully counterfeited Giacopo Bassan, as to deceive the most judicious, in many instances,

at the first sight; though, upon a closer inspection, his light and easy pencil, and a predominant gray tint, which is observable in the colouring of that master, show a perceptible difference between his pencil and colouring, when they are carefully examined and compared with Bassan's. (See *Pastici.*)

Piston, a moveable air-tight division within the steam-cylinder, acted upon by the steam. Pistons are either metallic or packed. Metallic pistons usually have segments of brass or cast iron, called junk-rings, pressed outward by springs. Packed pistons are surrounded by well-greased hemp.

Piston-rod, the rod fixed to the piston, to communicate its motion to the crank

Pitch, in building, the vertical angle of a roof, or the proportion between the heights and spans, as when the height is one-fourth, one-third, or one-half, of the breadth of the building. If the height is one-half of the breadth, the inclination of the planes, forming the vertical angle, is a right angle.

Pitching-piece, in staircasing, a horizontal piece of timber having one of its ends wedged into the wall, at the top of a flight of steps, to support the upper ends of the rough strings

Pitch-wheel. When two toothed-wheels work together, the circles of contact are called the proportional circles, or pitch circles.

Pit-man, one employed to look after the lift of pumps and the drainage

Pit-work, the pumps and other apparatus of the engine shaft

Pivot, a stud or small pin on which any thing turns

Pix, in church rituals, a little chest or box, in which the consecrated host is kept

Plain chart, in navigation, is a sea-chart, wherein the meridian and parallels are straight parallel lines, as in Mercator's projection; consequently the degrees of longitude are the same in all latitudes

Plain sailing, in navigation, the art of working a ship's motion on a plain chart, which supposes the earth to be an extended plane, or flat, and not globular

Plan. The plan of a building may be familiarly described as an architectural *map;* therefore only those who cannot comprehend a geographical or topographical map can be at any loss to understand an architectural one, the latter being precisely of the same nature as the others, with this difference in its favour, that it is much less conventional. To define it more exactly,—a plan is a *horizontal section* supposed to be taken on the level of the floor through the solid parts of the fabric—walls, columns, &c., so as to show their various thicknesses and situations, the dimensions of the several spaces or rooms, the position of the doors by which they communicate with each other, and various particulars that cannot otherwise be explained. Studying buildings without plans, is like studying geography without maps. A plan frequently costs the architect more study than all the rest of his design, and much mistaken are those who suppose that convenience alone has chiefly to be considered. Convenience is, of course, or ought to be, made a *sine quâ non;* yet it is not so much a positive merit in itself, as the want of it is a positive defect. Mere convenience is not an artistic quality: from that to beauty of plan,—to striking combinations, and studied effects, and varied play of arrangement,—the distance is very great. A common-place plan is but a very dull, uninteresting affair: it is no more than what any builder can accomplish; but a plan replete with imagination, piquant play, and well-imagined contrasts, is no every-day matter.

Planceer, the soffit or under side

the corona of a cornice, in Classical architecture

Plane, in surveying, a level surface, parallel to the horizon. In carpentry, an instrument by which the surfaces of bodies are smoothed.

Plane, inclined: in mechanics, this resembles one half of a wedge that has been cut in two parts lengthwise

Plane, in geometry, a plain level figure, or a surface lying evenly within its boundary lines

Planing Machine, an invention for diminishing the great labour of planing the surfaces of planks and boards of wood, and for reducing the surface to a true and smooth face, by means of planes, or instruments of a similar nature, which are actuated by the power of the machinery instead of the strength of a man's arm

Planing Machine. The invention of the 'slide-rest,' which has effected such an important improvement in cylindrical and conical turning, has been of far superior advantage in its application to the planing of surfaces, as the planing machine is but the slide-rest applied to a traversing table. In planing machines of the ordinary construction, the bed or basement frame has two angular ridges from end to end, one on each side, which fit into corresponding angular grooves in a traversing table. This table rests upon the ridges, and is moved backwards and forwards by a screw-rack and pinion, or chain: its surface is accurately planed, and the work being fastened upon it partakes of its motion, and is constrained to move in a perfectly straight line. Over the traversing table, at the centre of the machine, is fixed a slide-rest, which is held fast by being bolted to two upright standards fixed to the bed, one on each side. The *horizontal* slide has another at *right angles to it*, which serves to *hold the cutting* tool and adjust it *to the work*, so as to take a cut more or less deep, as required. To the long screw of the horizontal slide mechanism is connected, which causes it to advance the vertical slide and tool a very small distance across the machine, just before the commencement of each forward movement of the table; so that by a repeated series of movements to and fro of the table, the tool is made to traverse the whole surface of the work; and thus, by the perfectly level movement of the table in the one direction, and that of the slide in the other, a perfectly plane surface is obtained. In some machines the table is made to travel backward at a much faster rate than in the forward motion, so as to save time; and in others, the cutting tool acts in both movements, by being turned at the end of each.

Planish, in carpentry, &c., to smoothe, to polish

Planisher, a thin flat-ended tool, used by turners for smoothing brass-work

Planisphere, in geometry, &c., a sphere projected on a plane; such are maps of the heavens or of the earth

Plank, a term applied to all superficial timber which is 4 inches thick and under, except 1-inch, and sometimes 1½-inch, which come under the denomination of *board*

Plank-sheers, in ship-building, pieces of plank laid over the timber heads on the quarter-deck, forecastle, and round-house

Plane-tree, a native of Europe; it is also abundant on the banks of the Mississippi and Ohio. This, perhaps one of the largest of the American trees, is sometimes 12 feet in diameter, and is much used in that country for quays. It is used here for musical instruments, and other works requiring a clean light-coloured wood.

Plasm, in the arts, a mould; a matrix in which any thing is cast or formed

Plaster of Paris, in mineralogy and the arts, gypsum deprived of its water by burning, and reduced to a white powder, which is afterwards mixed with water. It serves many purposes in building, and is used likewise in sculpture, to mould and make statues, basso-relievos, and other decorations in architecture. It is dug out of quarries in several parts of the neighbourhood of Paris, whence its name. The finest is that of Montmartre. It is known also as gypsum.

Plastering, the art of covering the walls and ceilings of a house or other edifice with a composition, of which the groundwork is lime and hair mortar, finished with a coating of finer materials

Plat, in mining, ground appropriated to ore or deads

Plat-band, a flat fascia, band, or string, whose proportion is less than its breadth; the lintel of a door or window is also sometimes so named

Plate, and other services for the table. In the time of Henry VIII. and Elizabeth, amongst the numerous costly and magnificent articles for the table, wrought in silver, gold, and other precious materials, were chargers, dishes, plates, porringers, saucers, vases or cups, pots or tankards, flagons, pitchers, pottels, ewers, creuses, bowls, goblets, basins, washing-basins and ewers, horns, cups for caudle cruets, spice-plates, spiceries, salt-cellars, pepper-boxes, spoons, and candlesticks.

Plate, a term applied to horizontal timbers, placed on walls, &c., to receive other timber-work: that at the top of a building immediately under the roof is a wall-plate; those also which receive the ends of the joists of the floors above the ground floor are called the same

Plate-bending Machine. This invention was contrived for bending plates of metal into any required curve, and *is particularly useful* in the construction of boilers and the buckets of water-wheels: it consists of two side-frames, which carry three iron rollers and the spur-wheels and pinions necessary to communicate motion to two of them, one of which is placed immediately over the other, and can be raised or lowered by screws to the thickness of the plate to be bent. The third roller is placed behind the first two, and it is the height of this roller, with respect to that of the other two, that determines the degree of curvature of the plate: it is therefore made capable of adjustment by set-screws, and being placed to the proper height, and the machine set in motion, the plate is passed between the first two rollers, till, coming in contact with the third, it rises upward and takes the form of a curve.

Platina, yellow, is, as its name implies, a preparation from platina, which affords a series of yellow pigments, the deep colours of which resemble the Terra di Sienna, but are warmer in tone and richer in colour and transparency, much resembling fine gall-stones, for which they are valuable substitutes. They work well, and are permanent both in water and oil, when carefully prepared; but any portion of palladium in the metal from which they are prepared neutralizes their colour and renders them useless.

Platinum is found in the metallic state alloyed with other metals, but not in large quantities. It is not so white a metal as silver, but is very malleable and ductile, either when hot or cold. No furnace can melt it; but by the oxyhydrogen blow-pipe, or by a voltaic current, it is capable of being fused, and may be dissipated in the air. Alone it is insoluble in nitric acid, but when alloyed with other metals it is soluble.

Plenum, in physics, a term used to signify that state in which every part or space or extension is sup-

posed to be full of matter. It is used in opposition to vacuum.

Plinth, a square member forming the lower division of the base of a column, &c.; also the plain projecting face at the bottom of a wall, immediately above the ground. In Gothic architecture the plinth is occasionally divided into two stages, the tops of which are either splayed or finished with a hollow moulding, or are covered by the base mouldings.

Plinth, the square footing below the bases of Ionic and Corinthian columns. In Grecian architecture plinths do not appear to have been employed, the bases of the columns resting upon the upper step of the building. The Latin word *plinthus* is derived from the Greek, signifying a tile.

Plinthus, any rectangular parallelopiped; a brick or tile

Pliny, whose villas were by the Romans objects of much attraction, for their design and ornament, was a person of excellent judgment in all the useful arts, and, living under Trajan, had an opportunity of seeing the performances of and advising with Apollodorus, one of the greatest architects that any age produced: whether artists or masters employed by Pliny, or Pliny himself, designed these villas, is not to be determined; but Pliny was perfectly acquainted with the whole that was necessary to be understood in their situation and disposition

Plotting, among surveyors, the art of describing or laying down on paper, &c., the several angles and lines of a tract of ground surveyed by a theodolite or like instrument, or a chain

Plotting-scale, a mathematical instrument used in plotting ground, usually of box-wood, sometimes of brass, ivory, or silver, either a foot or a foot and a half long, and about an inch and a half broad

Plug-rod, the air-pump rod of a Cornish engine. The tappets which give motion to the valve are fixed upon these rods.

Plumb, in ship-building, signifies to be perpendicular

Plumbago forms gray tints of greater permanence and purity than most blacks in general use, and it is now employed for this purpose with approved satisfaction by experienced artists

Plumb-line, in architecture, &c., a line perpendicular to the horizon, made by dropping a plummet

Plummer-block, a short carriage or support for a shaft to turn in, with a flat base to bolt on a frame

Plummet, in carpentry, navigation, &c., a weight of lead hung on a string, by which depths are ascertained and perpendicularity discerned

Plum-tree, a handsome wood, a native of Europe, used principally in turning, and in Tunbridge works; in the endway of the grain it resembles cherry-tree

Plus, in algebra, a term commonly used for more, and denoted by the character +, as $6 + 10 = 16$, in contradistinction to −, or *minus*, less, as $16 - 10 = 6$

Pluteus, the wall which was sometimes made use of to close the intervals between the columns of a building, and was either of stone or some material less durable. The latter method was adopted only in places under cover, whence that kind of building was called *opus intestinum*. The pluteus was also a kind of podium, intervening between any two orders of columns placed one above the other. The word is used in this sense in the description of the basilica and the scene of the theatre. The pluteus has been adopted between every two orders of columns in the exterior of all the theatres and amphitheatres of the Romans which are known.

Pluviometer, in the arts, a rain-gauge, an instrument to measure the quantity of rain that falls

Plyers, in mechanics, a kind of balance used in raising or letting down a drawbridge

Plying to windward, in navigation, the endeavouring to make a progress against the wind

Pneumatics, the properties of air or fluids; a branch of hydrostatics

Pnyx, a name given to a place near Athens, at which assemblies were held for oratory, and for the discussion of political affairs of the state; the ancient place of the Athenian parliament. It was, according to Plutarch, describing the change effected by the Thirty Tyrants, in the aspect of the oratory, and was turned from the sea in order to divert the assembled people from being reminded by their orators of maritime affairs, the basis of Athenian dominion. No traveller, it is said, has hitherto remarked the circumstance of the position of the ancient city wall, by which the Pnyx was doubtless enclosed during and after the Peloponnesian war. Plutarch further remarks: "Themistocles did not bring the Piræus into the city, as Aristophanes would have had it; but he joined the city by a line of communication to the Piræus, and the land to the sea." This measure strengthened the people against the nobility, and made them bolder and more intractable, as the power came with wealth into the hands of masters of ships, mariners, and pilots. Hence it was that the oratory in the Pnyx, which was built to front the sea, was afterwards turned by the Thirty Tyrants towards the land, as they believed a maritime power to be inclinable to a democracy, whereas persons employed in agriculture would be less uneasy under an oligarchy.

Podium, in Greek architecture, a continued pedestal, for supporting a row of columns, or serving for a parapet, or forming a sort of terrace, as the podium of a theatre or amphitheatre. It consists of a plinth, base, die, and corona, all which were continued without interruption around three sides of the building. The podium was also adopted in the scenes of theatres; and here, instead of being uninterrupted, it was frequently broken round the basis of the columns, and formed what are commonly called pedestals. Vitruvius seems to consider the podium as a pedestal continued the whole length of a building, and to have been so called both when there were pillars placed on it, or only supported by a wall. When pillars were placed on the sides of buildings, sometimes, instead of having the podium continued the whole length in one line, it was made to break forward under every pillar, which part so advancing was called the stylobate, and that which was betwixt the pillars under the wall, was the podium.

Pointed or *Christian Architecture* had its rise about the 12th century. Very many beautiful examples exist in England. It was also employed in Germany. Mr. W. Pugin says, that Pointed architecture does not conceal her construction, but beautifies it. A buttress in pointed architecture at once shows its purpose, and diminishes naturally as it rises, and has less to resist. Here are the true principles of Christian architecture, by the conversion of an essential support of the building into a light and elegant decoration.

Point, in navigation, one of the thirty-two divisions into which the circumference of the horizon and the mariner's compass are distinguished, each comprehending 11° 15′

Point of horse, in mining, the spot where the vein is divided into one or more branches

Polacre, in navigation, a merchant vessel of the Mediterranean, having three pole-masts, without tops, caps, or cross-trees, with a bowsprit of one piece

Polarization. If a round hailstone drop upon the sloping roof of a house, it will act, as regards its rebound, just in the same manner whether the slope be towards the north, south, east, or west. But this will not be the case with an arrow under the same circumstances, because it has a distinction of sides, and its behaviour will vary according as the plane of its barbs is parallel with the eaves or with the rafters of the roof, or inclined to both. A bullet in its flight from a gun has also sides to its motion (though not to its form), because it revolves on an axis, which may be vertical, horizontal, or inclined; but if shot from a rifle, it has no such sides, because, though spinning on an axis, that axis has, by a particular contrivance, been made to coincide with its line of motion, so that it presents the same aspect above, below, or on either side. Now if these projectiles were too small or too rapid for us to discover the reason of these differences, we might still observe the differences themselves, and should express them by saying that the motion of the arrow or the gun-bullet possessed polarity, or polarization, which was not the case with that of the hailstone or the rifle-bullet. Polarity, then, means simply a difference of sides.

That a ray of light should (in some cases) possess this property, is not perhaps so wonderful or unexpected as that man should have been able to detect a fact so refined and remote from common observation, and even to distinguish different varieties of it, and investigate its laws. Indeed, these must be regarded as the very penetralia of physics, the very inmost secrets of Nature that man has been enabled to wrest from her. If the measurable spaces occupied by the waves of light be minute, how far less, in all probability, must be *those* immeasurable spaces to which its vibrations are confined (which even in sound are mostly inappreciable, though the waves occupy many feet); yet it is to the positions of these inconceivably minute vibrations that the differences of polarization are due.

Poldway, coarse sacking for coal-sacks, &c.

Pole-masts, in navigation, are those made of single trees or spars, in contradistinction to those made of several pieces

Pole-plate, a small wall-plate used in roofs to receive the pitch of the rafters

Polroz, in mining, the pit underneath a water-wheel

Polychromy is the art and practice of painting in positive colours, either on flat surfaces or sculptured forms, and has been referred for its origin to other than æsthetic motives. The object of polychromy is to heighten the effect of architectural decoration, either by causing a more just subordination of the various parts than can be obtained by mere chiaro-scuro, or in supplying deficiencies that could not be so well filled up by any other means. Professor Cockerell, who travelled and learned much in Greece, was the first who brought it to light in this country. This very interesting decorative art had its origin doubtless in Egypt; but the Greeks excelled, as in all art, by the existing evidence of the temples of their perfection of architectural art. The interior decorations of Pompeii are also evidences of a refinement of taste, and in Gothic polychromy the designers and operatives have shown some talent. A free and bold style in arabesque prevailed from the time of Henry III. until the close of the reign of Edward III. Bright and lively colours were applied to masses, and the grounds covered with compositions of foliage and birds, animals and human figures; sometimes in one

tint, sometimes in varied colours. Many beautiful examples still exist in our cathedrals and some parish churches.

Polyfoil, an ornament formed by a moulding disposed in a number of segments of circles

Polystyle, having a number of columns. Where columns occur behind columns, as where a portico has inner columns, like that of the Royal Exchange, such portico may be termed *polystyle*.

Pomel, a boss or knob used as an ornamental top of a conical or dome-shaped roof of a turret, &c. A large copper ball or pomel is on the summit of a timber spire of Lincoln cathedral.

Pons (Latin), a bridge. The most ancient bridge upon record is the one erected by Nitocris over the Euphrates at Babylon.

Poon wood, of Singapore, is of a light porous texture, and light greyish cedar colour; it is used in ship-building for planks, and makes excellent spars. The Calcutta poon is preferred.

Poplar wood. There are five species common to England, of which the *abele*, or great white poplar, and the Lombardy poplar, are most used. The woods are soft, light, easy to work, suited for carving, common turnery, &c.

Poppets, perpendicular pieces that are fixed on the fore and aftermost parts of the bulgeways, to support the ship while being launched

Poppet-head, that part of a lathe which holds the back centre, and can be fixed on any part of the bed

Poppy, an ornament representing the poppy-head, used on the tops of the upright ends or elbows which terminate seats, &c. in churches

Poppy-head, in architecture, a carved ornament at the apex of a standard or open seats in Gothic churches, also carved into an ornamental *finial, pomel or crest, &c.*

Porcelain clay, in mineralogy, a substance of great infusibility, derived from disintegrated felspar

Porch, in architecture, a roof supported on pillars before a door; a kind of vestibule supported by pillars. Any small portico considerably lower than the main structure to which it is attached may be so termed, in contradistinction from one carried up the height of the building, or as high as the principal cornice. Porches were used in Norman architecture, in Early English, and commonly in subsequent dates. When the fashion of building houses on quadrangular plans was discontinued, a porch of at least two stories, and sometimes the whole height of the building, succeeded the gate-house. Low porches had been used as entrances from inner courts from an early date; and of the time of Henry VIII. one may be mentioned at Cowdry, attached to the door leading from the court to the hall.

Pores, small interstices between the solid particles of bodies

Porisms, in geometry, a name applied by the ancients to certain comprehensive and indefinite problems

Port, in navigation, the larboard or left side of a ship; as 'a-keel to port' is an inclination to the larboard side

Ports, the holes in the ship to run the guns out

Port-lids, shutters to the ports

Ports and buildings constructed in water. Vitruvius writes: "The opportunity which presents itself of giving some account of ports, and by what means protection may be afforded to ships from the elements, ought not to be neglected. The positions best adapted by nature to such a purpose are bays with capes and promontories at their extremities, from which the shore recedes inwardly in a curved line. Upon shores of this description, docks may be built or porticoes erected, or a channel cut from the port to the emporium, defended by towe

on each side, in which machines may be constructed for throwing booms across the passage. If, however, no situation can be found capable by its formation of protecting vessels against the violence of the sea, we must search for a spot where a promontory presents itself on one side, and where no river discharges itself so as to oppose its application to the purposes of a harbour, and supply the want of a corresponding projection on the other by building walls and buttresses. The walls, which it becomes necessary in this case to construct in the water, may be thus formed: sand should first be procured from that part of the coast lying between Carnac and the promontory of Minerva, and mixed with lime in the proportion of two parts to one; then rows of grooved beams must be driven in the water, connected by oaken planks, and bound together by chains. The surface of the ground below the water, on which the wall is to be raised, must then be made even by means of transtilli, and the space comprehended between the beams filled with a composition consisting of rough stone and cement, made in the manner just described. Such is the quality of the sand produced in these spots, that the composition becomes a solid wall."

Port the helm. In navigation this phrase directs a ship's course further to the right, or starboard, by putting the helm to larboard.

Porta (Latin), the gate of a city, citadel, or other open space, enclosed by a wall, in contradistinction to *janua*, which was the door or entrance to any covered building

Portal, the arch over a door or gateway; an entrance under cover

Portcullis, a strong defensive framework of timber, hung in grooves within the chief gateway of a fortress, or a castle, or an edifice of safety: it resembles the harrow, but is placed vertically, having a row of iron spikes at the bottom, and is let down to stop the passage in case of assault

Portico, in architecture, a covered walk supported by columns, and usually vaulted; a piazza or arched pathway. (For the different plans and denominations of porticoes, see 'Rudimentary Architecture,' Part I.)

Porticus (Latin), a walk covered with a roof which is supported by columns. A portico was either attached to temples and public buildings, or it was built independent of any other edifice.

Porticus (deinde). In the houses of the Roman citizans, between the atrium (hall, or servants' room) and the inner court, there was usually a room called the *tablinum* (corridor), mentioned by Vitruvius. This porticus lay betwixt the atrium and the cavædium. The reason for his giving it this round form may be upon two accounts: first, to give a greater grace to its projection, and to make the fore part of it serve for a more beautiful vestibulum to the house; and in the next place, as being designed for a shelter in tempestuous weather, it the better broke the force of those winds that blew on that side than if it had been more square.

Porticus. By the Romans this was a common name given to all buildings that had walks under the cover of a roof or ceiling, supported by pillars or pilasters, though differently called, according to the disposition of the pillars: when placed on the outside of a building, as round some of their temples, it was called *peripterium;* when these ranges of pillars were within a room, as they were sometimes in their *triclinia, basilicæ, atria,* and temples, the void space betwixt the pillars and the side walls was called *alæ;* but when pillars surrounded courts, and had walks betwixt them and the walls,

these ranges of pillars were called *peristylia*, and the walk betwixt was called a *porticus*

Portland-stone, an alkaline sandstone, of a dull whitish colour, heavy and moderately hard, and somewhat flat texture, and composed of large rounded grit, cemented together by an earthy spar, and intermixed with numerous glittering spangles of pure spar: the grit splits in the cutting of the stone, so that it is capable of being brought to a surface very smooth and equal: it will not strike fire with a steel, and burns to a slight ashen hue. It has been and is much used for all kinds of buildings, particularly in the large structures in London: it is brought from the island of Portland, in Dorsetshire

Post, an upright timber in a building; those used in modern roofs are called king-posts or queen-posts, according to their number and position

Post Meridiem (*P.M.*), after mid-day

Postern, a small doorway or gateway at the back of a building; a small doorway for private communication with the exterior of a castle or fortress

Postique, in architecture, an ornament of sculpture superadded when the original plan has been completed

Pot-metal, a species of stained glass, the colours of which are incorporated within the glass while in a state of fusion

Poudrette, a French word, signifying powdered dung; but the word is applied, when treating of human excrement, in its meaning to the solid of that soil after the liquid manure has discharged itself. In a vine-growing district near Paris, (See article *Fosses d'aisances*,) poudrette was used for manure, and, although the application of it produced a great abundance of fruit, yet the wine proved very inferior to that which had been previously made on the same ground.

Power, in mechanics: this denotes a force which, being applied to a machine, tends to produce motion or pressure

Power, horse, in mechanics, an expression used to denote the power of a steam engine, that is to say, how many horses' work it will save. If a horse standing still can by his strength keep a weight of 169 lbs. from falling, when suspended over a pulley, he will exert 121 lbs. at two miles per hour; 100 lbs. at three; 81 lbs. at four; 64 lbs. at five; 49 lbs. at six; 36 lbs. at seven; 25 lbs. at eight; 16 lbs. at nine; 9 lbs. at ten; 4 lbs. at eleven; and 1 lb. at twelve miles per hour.

Power-loom, in mechanics, a loom moved by the mechanical force of steam, wind, water, &c., as contradistinguished from hand-weaving

Poyntell, paving formed into small lozenges or squares laid diagonally

Præcinctiones, the passages or corridors which separated the several ranges of seats in an ancient Roman theatre

Pressure of fluids consists of two kinds, elastic and non-elastic. The first is comprehended in the science of pneumatics, the second in that of hydrostatics. Both classes of fluids deviate from solid substances in their greater distribution of any pressure to which they may be subjected. Thus solid bodies press downwards only by the force of gravity; all fluids, on the contrary, press not only in this direction, but upwards, sideways, and every way equally. The incompressibility of water renders it serviceable, by this principle, in the hydrostatic press.

Preventer bolts, those which are driven at the lower end of the preventer plates, to assist the strain of the chain bolts

Preventer plates, in ships, plates of iron below the links of the chains

Pricker, a thin piece of iron, used to make a hole for the fusee or match to fire a blast

Prill, a solid piece of ore, a specimen

Priming, the effect engendered by having too little steam room in the boiler of a steam engine. Minute particles of water being carried into the cylinder, collect in a body, which obstructs the passage of the piston, and causes a considerable loss of power.

Prince's metal, in metallurgy, an alloy of copper, in imitation of silver, in which the proportion of zinc is greater than in brass

Principal brace, a brace immediately under the principal rafters or parallel to them, in a state of compression, assisting with the principals to support the timbers of a roof: they are employed in the present roof of St. Paul's church, Covent Garden

Priory, a monastic establishment for the devotional requirements and maintenance of a religious fraternity, under the government of a prior. Many priories were formerly scattered over Britain, as the subjoined list will show:

NAME.	ORDER.	DATE.	COUNTY.
Abergavenny . . .	Benedictine	Wm. Conq.	Monmouthshire
Abernethy	Augustine	1273	Perthshire
Acornbury	Do.	King John	Herefordshire
Alberbury	Black Monks	Henry I.	Shropshire
Aldeby		1355	Norfolk
Allensborne	Augustine	1466	Suffolk
All Saints	Do.	1166	Dublin
Alvingham		King Stephen	Lincolnshire
Andover			Hampshire
Anglesey	Augustine		Cambridgeshire
Appledercomb . . .	Benedictine	Henry III.	Hampshire
Ardchattan	Vallis Caulium	1230	Argyleshire
Astley	Benedictine	Wm. Conq.	Worcestershire
Aucot		1151	Warwickshire
Austin of Bradenstoke	Augustine	1142	Wiltshire
Austin Friars . . .		1253	Middlesex
Austin Priory of Bradley . . .	Do.	1230	Leicestershire
Austin Priory of Mickleham . .	Do.	Henry III.	Sussex
Austin Priory . . .	Do.	1358	Middlesex
Badlesmere	Do.	Edward II.	Kent
Bamborough . . .	Do.	Henry I.	Northumberland
Banester	Do.	1182	Oxfordshire
Bareham	Crutched Friars	Edward I.	Cambridgeshire
Barlinch	Augustine	Henry II.	Somersetshire
Barnstaple	Cluniac	Wm. Conq.	Devonshire
Barnwell	Augustine	1092	Cambridgeshire
Bartholomew (St.) .	Do.	1133	Middlesex
Basedale	Cistercian	1162	Yorkshire
Beaston	Augustine	King John	Norfolk
Beaulieu	Vallis Caulium	1230	Ross-shire
Beauvale	Carthusian	Edward III.	Nottinghamshire
Bees (St.)	Benedictine	Wm. Rufus	Cumberland
Belton-Grace-Dieu .	Augustine	1277	Leicestershire
Belvoir	Benedictine	1076	Lincolnshire
Bexdon	Augustine	1343	Essex

NAME.	ORDER.	DATE.	COUNTY.
Bicknacre	Augustine	Henry II.	Essex
Bilsington	Do.	1253	Kent
Binham	Benedictine	Henry I.	Norfolk
Birkenhead	Do.	Henry II.	Cheshire
Bissemede	Augustine	Henry II.	Bedfordshire
Bithkalest	Do.	1283	Caernarvonshire
Blackburn	Do.		Northumberland
Blackmore	Black Monks	King John	Essex
Blantyre	Augustine	1296	Lanarkshire
Blighburgh	Do.	Henry I.	Suffolk
Blythe	Benedictine	1088	Nottinghamshire
Bodmin	Augustine	1120	Cornwall
Bolton	Do.	1120	Yorkshire
Borgrove	Benedictine	Henry I.	Sussex
Botolph (St.) . . .	Augustine	Henry I.	Essex
Bourn	Do.	1138	Lincolnshire
Bradenstoke . . .	Do.	980	Wiltshire
Bradley	Do.	King John	Leicestershire
Bradwell.	Benedictine	King Stephen	Buckinghamshire
Brecknock	Do.	Henry I.	Brecknockshire
Bredon	Augustine	1144	Leicestershire
Bridgetown	Do.	1375	Cork
Bridlington	Do.	Henry I.	Yorkshire
Bridport			Dorsetshire
Brimsfield	Benedictine		Gloucestershire
Brinkburge	Augustine	Henry I.	Northumberland
Brisite	Do.	1110	Suffolk
Bromehill	Do.	Henry III.	Norfolk
Bromere	Do.	Henry I.	Hampshire
Bromfield	Benedictine	1155	Shropshire
Bromholm	Cluniac	1113	Norfolk
Brooke	Augustine	Richard I.	Rutlandshire
Bruton	Do.	1005	Somersetshire
Buckenham, Old . .	Do.	King Stephen	Norfolk
Bullington	Gilbertine	King Stephen	Lincolnshire
Burscough	Augustine	Richard I.	Lancashire
Bustlesham	Do.	1338	Berkshire
Butley	Do.	1171	Suffolk
Byrkley	Do.	1199	Somersetshire
Caermarthen . . .	Do.	1148	Caermarthenshire
Calderell.	Do.	1152	Bedfordshire
Camper	Do.	1244	Suffolk
Canonby	Do.	1296	Roxburghshire
Canons Ashby . . .	Do.	King John	Northamptonshire
Canwell	Benedictine	1142	Staffordshire
Cardiff	Do.		Glamorganshire
Cardigan.	Cistercian	1291	Cardiganshire
Careswell	Cluniac	Edward I.	Devonshire
Carisbrooke. . . .	Augustine	1071	Hampshire
Cartmele.	Do.	1188	Lancashire
Castleacre	Cluniac	1085	Norfolk
Castle Hymel . . .	Augustine	King John	Northamptonshire
Catteley	Gilbertine	King Stephen	Lincolnshire

NAME.	ORDER.	DATE.	COUNTY.
Charletan	Premonstrant	1187	Wiltshire
Chaucomb	Augustine	King John	Northamptonshire
Chepstow	Benedictine	King Stephen	Monmouthshire
Chetwood	Augustine	1244	Buckinghamshire
Chicksand	Gilbertine	1150	Bedfordshire
Chipley	Augustine	1468	Suffolk
Chirburg	Do.	Henry III.	Shropshire
Christchurch . . .	Do.	1150	Hampshire
Christchurch . . .	Do.	1108	Middlesex, within Aldgate
Clare	Do.	1248	Suffolk
Clattercote	Gilbertine	King John	Oxfordshire
Clifford	Cluniac	Henry I.	Herefordshire
Cogges	Augustine		Oxfordshire
Cokesford	Do.	Henry III.	Norfolk
Cold Norton . . .	Do.	Henry II.	Oxfordshire
Coldingham	Do.	673	Scotland
Coningshead . . .	Do.	Henry II.	Lancashire
Covenham	Benedictine	1082	Lincolnshire
Coventry	Do.	1043	Warwickshire
Cranbourne	Do.	980	Dorsetshire
Creak	Augustine	1226	Norfolk
Cresswell		King John	Herefordshire
Crusay	Do.	St. Columba	Argyleshire
Cumbwell	Do.	Henry II.	Kent
Daventry	Cluniac	Wm. Rufus	Northamptonshire
Denestro	Benedictine	Wm. Conq.	Somersetshire
Denhurst	Do.	980	Gloucestershire
Dennis (St.) . . .	Augustine	1124	Hampshire
Depyng		1139	Lincolnshire
Dodnash	Do.	Edward I.	Suffolk
Dorley	Do.	Henry I.	Devonshire
Dover	Benedictine	1140	Kent
Drax	Augustine	Henry I.	Yorkshire
Dudley	Cluniac	1161	Staffordshire
Dunmow	Augustine	1104	Essex
Dunstable	Do.	Henry I.	Bedfordshire
Earles Colne . . .	Benedictine	Henry I.	Essex
Easebourn	Nunnery	Henry III.	Do.
Edington	Augustine	1358	Wiltshire
Edithweston . . .	Benedictine	Henry I.	Rutlandshire
Ellerton	Gilbertine	1212	Yorkshire
Ellesham	Augustine	1166	Lincolnshire
Eltham	Do.	1166	Do.
Epworth	Carthusian	Richard II.	Do.
Erdbury	Augustine	Henry II.	Warwickshire
Essehold	Cistercian	1172	Yorkshire
Eston	Trinity	Henry III.	Wiltshire
Everdon		1217	Northamptonshire
Ewenny	Benedictine	1141	Glamorganshire
Ewyas	Do.	1100	Herefordshire
Eye	Do.	Wm. Conq.	Suffolk
Farley	Cluniac	1125	Wiltshire

NAME.	ORDER.	DATE.	COUNTY.
Feale	Cluniac		Ayrshire
Filley	Augustine	1156	Nottinghamshire
Finehale	Benedictine	1196	Durham
Flanesford	Augustine	1347	Herefordshire
Flitcham	Do.	Richard I.	Norfolk
Folkestone	Benedictine	630	Kent
Fordham	Gilbertine	Henry III.	Cambridgeshire
Frampton	Black Monks	Wm. Conq.	Dorsetshire
Freston		1114	Lincolnshire
Frothelstoke . . .	Augustine	1220	Devonshire
Fyvie		1179	Aberdeenshire
German (St.) . . .	Augustine	Henry I.	Cornwall
Gilbertine	Gilbertine	1291	Cambridge
Gilbertine	Sempring.	1212	Yorkshire
Goldcliff	Augustine	1113	Monmouthshire
Greenfield	Cistercian	1153	Yorkshire
Griesly	Augustine	Henry I.	Derbyshire
Grosmont			Yorkshire
Gwenny		1141	Glamorganshire
Gysburgh	Do.	1129	Yorkshire
Hackness		William II.	Do.
Hagh	Augustine	1164	Lincolnshire
Haltempraie . . .	Do.	1324	Yorkshire
Hampton	Do.	Henry I.	Norfolk
Hanepole	Cistercian	1170	Yorkshire
Harwolde	Augustine	1150	Bedfordshire
Hasilberge	Do.	1150	Somersetshire
Hastings	Do.	Richard I.	Sussex
Hatfield Broadoak . .	Benedictine	Henry I.	Essex
Hatfield Peverell . .	Do.	Henry I.	Do.
Hatfield Regis . . .	Black Monks	1135	Do.
Haverfordwest . . .	Augustine	1200	Pembrokeshire
Haverholm	Sempring.	1137	Lincolnshire
Hedley		1125	Yorkshire
Helagh	Augustine	1203	Do.
Helen's (St.) . . .	Cluniac	1155	Hampshire
Heringham	Augustine	1472	Sussex
Herringfleet . . .	Do.	Henry III.	Suffolk
Hertford	Benedictine	1223	Hertfordshire
Hertland	Augustine	1000	Devonshire
Hickling	Do.	1185	Norfolk
Hinkley	Benedictine	1173	Leicestershire
Hinton	Carthusian	1222	Somersetshire
Hitchen	Gilbertine	Edward III.	Hertfordshire
Holland	Benedictine	1319	Lancashire
Holland Brigge . .	Sempring.	King John	Lincolnshire
Holme	Cluniac	1291	Dorsetshire
Holycourt	Benedictine	Saxon period	Norfolk
Holy Trinity . . .	Do.	1089	York
Holywood	Premonstrant	1296	Kirkcudbrightshire
Horkesley Parva . .	Cluniac	Henry II.	Essex
Hornby	Premonstrant		Lancashire
Hornchurch . . .		Henry II.	Essex

NAME.	ORDER.	DATE.	COUNTY.
Horsham	Benedictine	1105	Norfolk
Horsley		Wm. Conq.	Gloucestershire
Hounslow	Trinity	Edward I.	Middlesex
Hoxne	Benedictine		Suffolk
Huntingdon	Augustine	King Steph.	Huntingdonshire
Hurley	Benedictine	William I.	Berkshire
Hyrst	Augustine	Henry I.	Lincolnshire
Ipswich	Do.	1177	Suffolk
Isle of May . . .	Do.	David I.	Fifeshire
Ives (St.)	Benedictine	1001	Huntingdonshire
Ivychurch	Augustine	Henry II.	Wiltshire
Ixworth	Do.	1100	Suffolk
Kersey	Do.	Edward III.	Do.
Kidwelly	Benedictine	1130	Caermarthenshire
Kilcomin	Do.	1184	Tipperary
Kilpeck	Do.		Herefordshire
Kingston	Carthusian	Edward III.	Yorkshire
Kirby Beler . . .	Augustine	1359	Leicestershire
Kirkham	Do.	1121	Yorkshire
Knaresborough . .	Trinity	King John	Do.
Kyme	Augustine	Henry II.	Lincolnshire
Lancaster	Benedictine	1004	Lancashire
Lanercost	Augustine	1169	Cumberland
Lantony	Do.	1108	Monmouthshire
Lantony	Do.	1136	Gloucestershire
Lapley	Black Monks	Edw. Conf.	Staffordshire
Latten	Augustine	1270	Essex
Launceston . . .	Do.	1126	Cornwall
Laund	Do.	1125	Leicestershire
Leeds	Do.	1119	Kent
Lees, or Lighes . .	Do.	Henry III.	Essex
Lenton	Cluniac	Henry I.	Nottinghamshire
Leominster		660	Herefordshire
Letheringham . . .	Augustine		Suffolk
Lewes	Cluniac	1078	Sussex
Lintin		Henry III.	Cambridgeshire
Lochleven	Augustine		Kinross-shire
Loch Tay	Do.	Alex. I. 1122	Perthshire
Lodres		Henry I.	Dorsetshire
Long Bennington . .	Cistercian	1175	Lincolnshire
Longlent	Augustine	1291	Wiltshire
Lynn	Benedictine	1100	Norfolk
Lythom	Do.	1291	Lancashire
Luffield	Do.	1124	Northamptonshire
Mabberly	Augustine	1206	Cheshire
Maldon	Carmelite	1292	Essex
Malvern Major . .	Benedictine	1083	Worcestershire
Malvern Minor . .	Do.	1171	Do.
Mardin Bradley . .	Augustine	King Stephen	Wiltshire
Markby	Do.	Henry II.	Lincolnshire
Marlborough . . .	Gilbertine	King John	Wiltshire
Marmond	Do.	Richard I.	Cambridgeshire
Marstoke	Augustine	1336	Warwickshire

NAME.	ORDER.	DATE.	COUNTY.
Martin (St.) . . .			Kent
Massingham Magna .	Augustine	1260	Norfolk
Mattersey	Gilbertine	1192	Nottinghamshire
Maxtoke	Augustine	1336	Warwickshire
May		David I.	Fifeshire
Melton Mowbray . .	Cluniac		Leicestershire
Mendham	Do.	King Stephen	Suffolk
Menton	Augustine	1196	Yorkshire
Mereval	Cistercian	King Stephen	Warwickshire
Mersey	Benedictine	Edw. Conf.	Essex
Merton	Augustine	1121	Surrey
Michael (St.), Mount .	Benedictine	Edw. Conf.	Cornwall
Minster Lovel . . .	Do.	King John	Oxfordshire
Mixhalham . . .	Augustine	Henry III.	Sussex
Modbury	Benedictine	King Stephen	Devonshire
Molycourt	Do.	Wm. Conq.	Norfolk
Monimusk	Augustine	William the Lion	Aberdeenshire
Monk Breton . . .	Cluniac		Yorkshire
Monkland	Benedictine	Henry II.	Herefordshire
Monks Horton . .	Cluniac	Henry II.	Kent
Monks Kirby . . .	Benedictine	Henry II.	Warwickshire
Monmouth	Do.	Henry I.	Monmouthshire
Montacute	Cluniac	Henry I.	Somersetshire
Morfield	Benedictine		Shropshire
Motesfort	Augustine	King John	Hampshire
Mottenden	Trinity	1124	Kent
Mountgrave . . .	Carthusian		Yorkshire
Mountjoy	Benedictine	1264	Norfolk
Nanah	Augustine	1200	Tipperary
Neot's (St.) . . .	Benedictine	1113	Huntingdonshire
Nesseham	Do.	King John	Durham
Newark	Augustine	1121	Surrey
Newburgh	Do.	1145	Yorkshire
Newent	Benedictine	Wm. Conq.	Gloucestershire
Newington Longaville	Cluniac	Henry I.	Buckinghamshire
Newnham	Augustine	Henry II.	Bedfordshire
Newsham	Gilbertine	1173	Lincolnshire
Newsted	Augustine	1170	Nottinghamshire
Newstede	Gilbertine	Henry III.	Lincolnshire
Nocton	Do.	King Stephen	Do.
Normannesbirch . .	Cluniac	1160	Norfolk
Northampton . . .	Do.	1076	Northamptonshire
North Fernby . . .	Augustine		Yorkshire
North Ormesby . .	Gilbertine	King Stephen	Lincolnshire
Norton	Augustine	1330	Cheshire
Nostell	Do.	Henry I.	Yorkshire
Nutley	Do.	1162	Buckinghamshire
Oegmild	Benedictine	1202	Ireland
Okeburn	Do.	1149	Wiltshire
Old Malton	Gilbertine	1150	Yorkshire
Oveton	Do.	King John	Do.
Ovingham	Augustine		Northumberland

NAME.	ORDER.	DATE.	COUNTY.
Panfeld	Benedictine	Wm. Conq.	Essex
Pembroke	Do.	1098	Pembrokeshire
Penmon	Do.	1221	Anglesea
Peterson	Augustine	1200	Norfolk
Pille	Benedictine	1200	Pembrokeshire
Pilton		1200	Devonshire
Pinnortham	Benedictine	Wm. Conq.	Lancashire
Pintney	Augustine	Do.	Norfolk
Pittenweem	Do.		Fifeshire
Pluscardine	Vallis Caulium	1230	Moray
Plympton	Augustine	1121	Devonshire
Pontefract	Cluniac	Wm. Rufus	Yorkshire
Porchester	Augustine	1133	Hampshire
Port Moack . . .	Do.		Kinross-shire
Poughley	Do.	1160	Berkshire
Priory in the Wood .	Carthusian	Richard II.	Lincolnshire
Prittlewell	Cluniac		Essex
Pulton	Gilbertine	Edward III.	Wiltshire
Pyneham	Augustine	1151	Sussex
Ramestede	Benedictine	Henry II.	Do.
Ratlingcope	Augustine		Shropshire
Ravenston	Do.	Henry III.	Buckinghamshire
Redholm	Cistercian	Henry I.	Yorkshire
Restennote	Augustine	1296	Forfarshire
Rhudland	Black Friars	1268	Flintshire
Rindelgros		1124	Perthshire
Ripton	Augustine	1172	Derbyshire
Ronton	Do.	Henry II.	Staffordshire
Rosneth	Do.		Dumbartonshire
Roucester	Do.	1146	Staffordshire
Rowadill	Do.		Ross-shire
Royston	Do.	Henry II.	Herefordshire
Rumburgh	Benedictine	1064	Suffolk
Ryegate	Augustine	1200	Surrey
Sandford	Do.	1205	Berkshire
Sandleford	Do.	1114	Do.
Sandwell	Benedictine	Henry II.	Staffordshire
Scokirke	Augustine	1114	Yorkshire
Scurinoke	Do.		Ross-shire
Selburne	Do.	1233	Hampshire
Sele	Benedictine	1075	Sussex
Sempringham . . .	Gilbertine	1139	Lincolnshire
Shelbred	Augustine		Sussex
Shelford	Do.	Henry II.	Nottinghamshire
Shenburn (West) . .	Benedictine	Henry I.	Hampshire
Shene	Carthusian	1444	Surrey
Shouldham	Gilbertine	Richard I.	Norfolk
Sixhill	Do.		Lincolnshire
Snape	Benedictine	1155	Suffolk
Snelleshall	Do.	Henry III.	Buckinghamshire
Soul's Seat	Premonstrant	1296	Kirkcudbrightshire
South wyke	Augustine	1133	Hampshire
bury		Henry I.	Dorsetshire

NAME.	ORDER.	DATE.	COUNTY.
Spinney	Augustine	Henry III.	Cambridgeshire
Spinney	Do.	Edward I.	Do.
Stanesgate	Cluniac	1176	Essex
Stanley		1146	Gloucestershire
Stanley St. Leonard .	Benedictine	1146	Do.
Staverdale	Augustine	1263	Somersetshire
St. Andrew	Benedictine		Ulster
St. Andrew	Cluniac	1076	Northamptonshire
St. Andrew at York .	Sempring.	1200	Yorkshire
St. Catherine . . .	Do.	1148	Lincoln
St. Clare	Cluniac	1291	Caermarthenshire
St. Denys	Augustine	1124	Hampshire
St. Dogmel's . . .	Tyrone	Wm. Conq.	Pembrokeshire
St. Faith, at Horsham		1105	Norfolk
St. Guthlac	Benedictine	about 1000	Herefordshire
St. James	Cluniac	1140	Derby
St. James	Do.	1157	Exeter
St. James	Benedictine	1147	Bristol
St. John the Evangelist	Augustine	1211	Kilkenny
St. Julian	Do.	1107	Essex
St. Leonard		1394	Norwich
St. Leonard, Stamford		658	Lincolnshire
St. Martin	Benedictine	1146	Yorkshire
St. Martin	Do.	640	Dover
St. Mary's Isle . . .		David I.	Kirkcudbrightshire
St. Mary Magdalen .	Do.	1291	Lincolnshire
St. Mary Overy . .	Augustine	1106	Surrey
St. Neot's	Benedictine	850	Huntingdonshire
St. Osith	Augustine	635	Essex
St. Oswalde . . .	Do.	909	Gloucester
Sts. Peter and Paul, Ipswich	Do.	Henry II.	Suffolk
St. Thomas	Do.	1172	Dublin
St. Thomas	Do.	1180	Stafford
Stevesholm	Cluniac	King Stephen	Norfolk
Steyning . . .	Benedictine	Wm. Conq.	Sussex
Stoke Curry . .	Do.	Henry II.	Somersetshire
Stone	Augustine	Henry I.	Staffordshire
Stoneley	Do.	1180	Huntingdonshire
Strathfillan	Do.	Robt. Bruce	Perthshire
Studley	Do.	Henry II.	Warwickshire
Sudbury	Benedictine	1139	Suffolk
Swavesay	Do.	William I.	Cambridgeshire
Tandridge	Augustine	1308	Surrey
Taunton	Do.	Henry I.	Somersetshire
Thetford	Cluniac	1103	Norfolk
Thetford	Do.	1114	Norfolk
Thoby	Augustine	1141	Essex
Thornham	Do.	King Stephen	Lincolnshire
Thorsling	Do.		Cambridgeshire
Thremhale	Do.	Wm. Conq.	Essex
Thurgarton	Do.	1130	Nottinghamshire

NAME.	ORDER.	DATE.	COUNTY.
Tickford	Cluniac	William II.	Buckinghamshire
Tinmouth	Benedictine	633	Northumberland
Tiptree	Augustine	Edward I.	Essex
Toberglorie	Do.		Down
Tooting	Black Monks	Wm. Conq.	Surrey
Torkesay	Augustine	King John	Lincolnshire
Tortington	Do.	1376	Sussex
Tortington	Do.	ante John	Do.
Totness	Benedictine	Wm. Conq.	Devonshire
Trentham	Augustine	783	Staffordshire
Tristernagh	Do.	1217	Westmeath
Tukeley		Henry I.	Essex
Tunbridge	Do.	Henry I.	Kent
Tunbridge	Do.	Richard I.	Surrey
Tunstal	Gilbertine	King Stephen	Lincolnshire
Tutbury	Benedictine	1080	Staffordshire
Tykeford	Cluniac	1291	Buckinghamshire
Tywardreth . . .	Benedictine	1169	Cornwall
Twinham	Augustine	1150	Hampshire
Ulverscroft	Do.	Edward II.	Leicestershire
Urquhart	Benedictine	David I. 1225	Moray
Usk	Do.	1236	Monmouthshire
Vaudey	Cistercian	1147	Lincolnshire
Wallingford . . .	Benedictine	William I.	Berkshire
Walsingham . . .	Augustine	1061	Norfolk
Walton St. Felix, &c. .		1105	Suffolk
Wanford	Cluniac	1160	Do.
Ware		1081	Hertfordshire
Wareham		Henry I.	Dorsetshire
Warmington . . .	Benedictine	Henry I.	Warwickshire
Wartre	Augustine	1132	Yorkshire
Warwick (St. Sepulchre)	Do.	Henry I.	Warwickshire
Watton	Gilbertine	1150	Yorkshire
Wayburn	Augustine	Henry II.	Norfolk
Weedon Pinkney . .	Benedictine	Henry I.	Northamptonshire
Welles	Gilbertine	Richard I.	Cambridgeshire
Wells	Benedictine	Wm. Conq.	Norfolk
Wenlock	Cluniac	Wm. Conq.	Shropshire
Westacre	Augustine	Wm. Rufus	Norfolk
Wetherall	Benedictine	about 1000	Cumberland
Weybridge	Augustine	Edward I.	Norfolk
Whitshorn	Premonstrant	David I.	Kirkcudbrightshire
Wilmington . . .	Benedictine	Wm. Rufus	Sussex
Wingall			Lincolnshire
Winge	Benedictine	King Stephen	Buckinghamshire
Withain	Carthusian	1181	Somersetshire
Wolenchmere . . .	Augustine	Henry III.	Sussex
Wombridge . . .	Do.	Henry I.	Shropshire
Woodbridge . . .	Do.	1200	Suffolk
[illegible]lheuse	Do.	1250	Shropshire
[illegible]	Do.	Henry I.	Yorkshire
[illegible] . .	Benedictine	Henry I.	Warwickshire

NAME.	ORDER.	DATE.	COUNTY.
Worksop	Augustine	Henry I.	Nottinghamshire
Wormegay	Do.	1468	Norfolk
Wormeleye	Do.	King John	Herefordshire
Worspring	St. Victor	1210	Somersetshire
Wrangford	Cluniac	1160	Sussex
Wroxton	Augustine	Henry III.	Oxfordshire
Wymondsley . . .	Do.	Henry III.	Hertfordshire
Yarmouth	Benedictine	1101	Norfolk

Prism, in geometry, a body or solid whose two-thirds are any plane figures which are parallel, equal, and similar, and its sides parallograms

Prism, in optics, a triangular bar of glass, well known from the effect it produces on a ray of light transmitted through it: this effect is a decomposition of the light into its component emanations, consisting of the three primary colours and the secondary tints arising from their intermixture, which together form what is termed the *solar spectrum*. The lensic prism is a new optical glass, in which the powers of the lens and prism are combined.

Prison, an edifice, unfortunately mostly of large dimensions, for the confinement of persons warring against society

Profile, the outline of a series of mouldings, or of any other parts, as shown by a section through them

Profile of an Order, in architecture, an assemblage and arrangement of essential and subservient parts. That profile is preferable wherein the parts are few, varied, and fitly applied. Some member should predominate in each division, which it should appear the office of the other parts to fortify, support, or shelter. In a cornice the corona is supported by modillions, dentils, ovolos, &c., and sheltered and covered from the effects of the weather by its cyma or cavetto.

Projectile, in mechanics, a body put *in motion by an external force*

Projectiles, in mechanics, that branch which considers the mass, velocity, range, &c. of a heavy body projected into void space by an external force, and then left to the free action of gravity

Projection, in geometry, drawing, &c., a plan or delineation; in chemistry, the crisis of an operation

Projecture, in architecture, the outjutting or prominence which the moulding and members have beyond the plane of a wall or column

Prolate, in geometry, an epithet applied to a spheroid produced by the revolution of a semi-ellipsis about its long diameter

Pronaos, the area immediately before a temple. The term is often used for the portico in front of a building. The posticus in one front corresponds to the pronaos in the other: in some temples, the cella was entered through both. The generality of Grecian temples had two approaches.

Proportion, in architecture, the magnitude of one part as compared with some other. The term 'proportion' is used absolutely in the sense of 'good proportion,' although every thing that has shape has proportions of some kind or other. The subject of proportion has been greatly mystified by writers, who have laid down certain fixed proportions as the best of all on every occasion, and as the *ne plus ultra* of artistic taste. But fixed proportions can be followed mechanically by every one alike; whereas it requires ability to deviate successfully from routine measurement, an apply the poco più or the poco m as the particular occasion or

particular effect aimed at may require—at least, justify. It is the eye that takes cognizance of proportions; and the architect's own eye ought to be quite as correct as that of other people.

Proportion, that branch of mathematical science which defines the ratio of numbers or quantities to each other

Proportions of rooms should be suited to the purposes for which they are used: all figures, from the square to one and a half the breadth of the room, may be employed for the plan. Some have extended the plan to a double square. Galleries may be from five to eight times their breadth. The height, if with flat ceilings, is not required to be so great as in those that are coved. The height of square apartments should not exceed five-sixths the side of the square, nor be less than four-fifths; but in rooms that are oblong, the height ought to be equal to the breadth. The height of square rooms that are coved should be equal to one of the sides of the square; but coved oblong rooms require a height equal to the breadth, added to one-fifth, one-quarter, or, at most, one-third of the difference between their length and breadth. The height of galleries should be from one and three-fifths, at most, to one and one-third, at least, of their breadth. Cornices and dressings in the interior of houses are always to be kept more delicate than those on the outside.

Propylæum, in Greek architecture, the porch of a temple or great hall

Propylæa: the entrance to a Greek temple, a sacred enclosure, consisted of a gateway flanked by buildings, whence the plural of the word. The Egyptian temples generally had magnificent propylæa, consisting of a pair of oblong truncated pyramids of solid masonry, the faces of which were sculptured with hieroglyphics. The word, however, is generally used to signify th trance to the acropolis of At which was the last complet the great works of archite executed under the administr of Pericles. Pausanias relates "there is only one entrance t acropolis, it being in every maining part of its circuit a p pice, and fortified with strong v This entrance was fronted magnificent building, called propylæa, covered with roo white marble, which surpasse beauty, and the dimensions o marble, all that he had before s The building was commenced d the administration of Pericles, finished in five years, Mne being the architect, at the exp of 2012 talents, or nearly £464 sterling. There were five gat the propylæa, and before it two lofty piers, on each of w was placed an equestrian st supposed to be the sons of X phon. On the right of the pylæa was the temple of Vic without wings, whence is a spect of the sea; and from this p it was said that Ægeus threw self down headlong, and died. the left of the propylæa wa edifice adorned with paintings, work of Polygnotus, of which, Pausanias, though some were faced by time, there still rema those of Diomedes and Uly the one bearing off the bow arrows of Philoctetes from Lem the other, the Palladium Troy. There were those als Orestes slaying Ægisthus, and lades encountering the sons of plius, who had come to suc Ægisthus; Polyxena, at the pulchre of Achilles, about to b crificed, and Ulysses addressing self to Nausicaa and her maiden described by Homer. Several o pictures in the same place described by Pausanias. T three contiguous buildings nally formed one front, occ

the whole breadth of the rock from side to side, at its western end, so that the only admission into the acropolis was through the middle building, the five gates of which are still remaining, and prove it to have been the propylæa. It may be supposed that the Hermes Propylæus was here placed, and perhaps the Graces, a piece of sculpture by the hand of Socrates, in which that celebrated philosopher, deviating from the practice of the sculptors who preceded him, had represented them not naked but clothed. Other sculptors are also mentioned by Pausanias who seem to have decorated this stately entrance.

Proscenium, the area in front of the scene of a theatre, which was perceived when the pulpitum was removed, and when it is probable the temporary scenes were taken away in order to exhibit the front of the permanent scene

Prostyle, a temple which has a portico in one front, consisting of insulated columns with their entablatures and fastigium. When the temple had a portico in both fronts, it was termed amphi-prostyle, or prostyle in all parts.

Protractor, in surveying and trigonometry, an instrument by which angles taken in the field with a theodilite-circumferentor are represented on paper

Prow, in navigation, the head or forepart of a ship, in opposition to the poop or stern

Prussian Blue, otherwise called Berlin blue, Parisian blue, Prussiate of iron, cyanide of iron, or, in language more pedantically chemical, per-ferro-cyanate of iron, with alumine, &c., is rather a modern pigment, produced by the combination of the prussic or hydrocyanic acid, iron, and alumina. It is of a deep and powerful blue colour, of vast body and considerable transparency, and forms tints of much beauty with white-lead, though they are by no means equal in purity and brilliancy to those of cobalt or ultramarine, nor have they the perfect durability of the latter.

Prussian Brown is a preparation of Prussian blue from which the blue colouring principle has been expelled by fire, or extracted by an alkaline ley: it is an orange brown, of the nature and properties of Sienna earth, and dries well in oil

Prussian Green. The pigment celebrated under this name is an imperfect prussiate of iron, or Prussian blue, in which the yellow oxide of iron superabounds, or to which yellow tincture of French berries has been added, but is not in any respect superior as a pigment to the compounds of Prussian blue and yellow ochre. A better sort of Prussian green is formed by precipitating the prussiate of potash with nitrate of cobalt.

Prussiate of Copper differs chemically from Prussian blue only in having copper instead of iron for its basis. It varies in colour from russet to brown, is transparent and deep, but being very liable to change in colour by the action of light or by other pigments, it has been very little employed by artists

Pryan, in mining, that which is productive of ore, but does not break in large stones, but only in pebbles with a mixture of clay

Pseudo-dipteral, a temple which has a single range of columns in the flanks, at the same distance from the walls of the cella as though the temple had been dipteral

Pteroma, the spaces between the walls of the cella of a temple and the columns of a peristyle; called also *ambulatio*

Puddling, in metallurgy, a process in the refining of iron which consists in stirring it actively about

Pulley, one of the six mechanical powers. The pulley is a small wheel turning on an axis, with a rope or chain passing over it. T

circumference is generally grooved to receive the rope, which is attached on the one end to the moving power, and on the other to the resisting force. Pulleys are of two kinds—fixed and moveable. The fixed pulley gives no mechanical advantage, but is of great utility in altering the direction in which it may be applied. The moveable, on the contrary, doubles the power, which may be increased in any ratio by adding to the number of pulleys. In a combination of pulleys, the advantage, however, is greatly diminished by the friction of the axles and of the ropes. Too complex a combination therefore would not be of service, as the friction would be increased without a proportional advantage, and from the complexity of the machine would be more liable to be put out of order.

Pulpit, an elevated stage or desk from which sermons are delivered. (For beautiful examples, see Mr. Parker's 'Glossary of Architecture,' and the 'Papers on Architecture,' 4 vols. 4to.)

Pulpitum, the wooden stage of the theatre upon which the mimic as well as dramatic exhibitions of the Romans were represented. In the Greek theatre, the pulpitum was used only by the histriones, or performers in the drama, and was probably removed before the amusements of the orchestra were exhibited.

Pulvinated. A frieze whose face is convex instead of plain is said to be pulvinated, from its supposed resemblance to the side of a cushion, which swells out when pressed upon.

Pump, an engine for raising liquids, made in various forms, of more or less complexity of parts and effectiveness of action, depending in its simplest form upon the external pressure of the air on the surface of the water, and in other forms deriving its power from the abstraction of the air within the tube or barrel. The simplest form of pump is that of the common lift-pump, which consists of a straight tube with two valves, one of which is fitted to the lower end of the tube, and the other is made to slide air-tight in the cavity of the tube or barrel. Both of these valves are adapted to open upwards only, and thus the water is admitted and lifted from the lower part of the tube to the discharge aperture above. This pump acts by the pressure of the atmosphere upon the external body of water from which the supply is raised, but by the forcing-pump water may be raised above the level to which it is driven by the pressure of the atmosphere. The forcing-pump consists of a barrel fitted with a solid piston or forcer, the barrel being also provided with a branch forcing-pipe. The lower part of the barrel and the branch pipe are each fitted with a valve opening upwards, and by repeated strokes of the piston, the pressure of the air from above being removed, the fluid is brought up to fill the space between the two valves, and being prevented from returning by the lower valve, it passes through the upper valve of the branch pipe into a capacious upper vessel, and there accumulating, may be ejected in a constant instead of intermittent stream. The lift-pump, being simple and economical in construction, is well fitted for extensive works in which the quantity of water to be raised is considerable, and is therefore usually employed in works for supplying water for towns. The pumps used at the Metropolitan and other water-works are of great size, and deliver immense volumes of water at each stroke. Those used at Haarlem are 63 inches in diameter, and the pistons have a stroke of 10 feet in length. Each pump delivers 6 tons of water at each stroke. Pumps of this magnitude are worked by water or steam

power. Those at Haarlem, eleven in number, are worked simultaneously by a steam engine, having two steam cylinders, one within the other, the larger being 12 and the smaller 7 feet in diameter, with a stroke of 10 ft. (See *Forcing-Pump.*)

Pump. Mr. Appold's centrifugal pump for draining marshes, and for other purposes, will discharge 10 gallons of water per minute, and is only 1 inch diameter: one of the same shape, 12 inches diameter, will discharge at the same speed of the outside circumference, or $\frac{1}{12}$ the number of revolutions, 1440 gallons per minute, being according to the square of the diameter, and not according to the cubic contents. From various experiments, it has been found that the larger model with the curved vanes does the most duty, on account of its receiving and delivering the water more obliquely: it will discharge 1800 gallons per minute, with 607 revolutions, but does the most duty at 535 revolutions, discharging 1400 gallons; therefore, if a pump 1 inch diameter raise 10 gallons, and another 1 foot diameter 1440 gallons, it follows that one

	gals. per min.
10 feet diameter, of the best shape, will pump	140,000
20 ditto, ditto . . .	560,000
40 ditto, ditto . . .	2,240,000

To do the above duty, the circumference of the 20-feet pump would be required to travel 560 yards per minute, which would be only 53½ revolutions, and the 40-feet 26¾.

From the results of various experiments, it has been found that the loss of power would not be more than 25 per cent. It will be observed, the centrifugal force is not so much in the large diameter, on account of the water moving *more in a straight line*; but that is *compensated for by the force being* applied to a greater depth of water, being 10 feet in the 40-feet, and only 3 inches in the 1-foot.

	ft. high.
159 revolutions, with the 1-foot, will raise the water, without discharging any,	1
318 revolutions	4
636 ditto	16
1272 ditto	64

The highest elevation to which the water has been raised with the 1-foot pump, is 67 feet 8 inches, with 1322 revolutions per minute, being less than the calculated height, which may be accounted for by leakage with the extra strain.

While the 1-foot pump is raising 8 tons of water 5 feet 6 inches high per minute, there is no greater strain on any part of the pump than 160 lbs. on the 6-inch drum, which is equal to a leverage of 3 inches. (See the results of various experiments in the Table on the the next page.) It will pass almost any thing that is small enough to go through, there being no valves. A quantity of nut-galls (about ½ a gallon) were thrown into the 1-foot pump all at once, when it was at full speed, and they passed through without breaking one.

Dimensions of the Pump.

Diameter	1 foot.
Width	3 inches.
Contents	1 gallon.

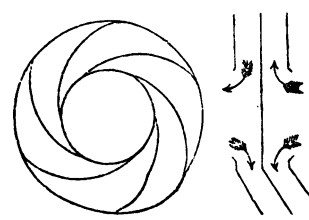


Table of Mean Results of various Experiments with Mr. Appold's Centrifugal Pump.

No. of revolutions per minute of 6-inch drum and pump.	Number of gallons raised 5 feet 6 inches high per minute.	Equivalent in lbs. raised 1 foot high per minute.	Strain in lbs. on a drum of 4 ft. diameter driving one of 6 in. diameter, as measured by a dynamometer.	Equivalent strain on the steam engine, rated in lbs., raised 1 foot high per minute.	Per centage of work done compared with power expended.
400	500	27,500	74	44,400	61·7
412	600	33,000	80	49,440	66·7
427	700	38,500	87	55,723	69·
440	800	44,000	94	62,010	70·9
453	900	49,500	100	67,950	72·8
474	1000	55,000	106	75,366	72·9
481	1100	60,500	113	81,479	74·2
495	1200	66,000	118	87,615	75·3
518	1300	71,500	121	94,017	76·
535	1400	77,000	126	101,115	76·1
563	1500	82,500	134	113,163	72·9
580	1600	88,000	138	120,060	73·3
595	1700	93,500	142	126,733	73·6
607	1800	99,000	150	136,575	72·5

Pump, marine, a machine to draw water out of a ship's hold

Pump-chain. This consists of a long chain with valves at proper distances, working on two wheels, one above and one below, and passing down through one wooden tube and returning upwards by another.

Pump-cistern, to receive the water from the pumps

Pump-dales, pipes to convey water from the pump-cisterns through the ship's sides

Pumping engine, a steam engine for raising water

Punch, in mining, a piece of timber used as a support for a roof

Punch, a tool for making an impression, or for forcing a hole through a plate

Puncheon, a measure of liquids containing eighty-four gallons

Puncheons, small upright timbers in wooden partitions, now usually [illegible]led studs or quarters; they are [illegible]ed upright between two posts [illegible] bearing is too great, serving, together with them, to sustain some large weight

Punching and Plate-cutting Machine. The operation of punching holes through thick metal plates requires machinery of a very massive description, on account of the violent strains to which it is subjected; and the power of these machines being exerted only at intervals, it is necessary to apply some means of rendering the motion tolerably uniform, and thereby diminishing as much as possible the violence of the strain. This is effected by setting in motion a heavy fly-wheel, so that the power expended in giving a certain velocity to the wheel shall be stored up till the operation of punching commences, which tends to retard the motion: the accumulated power in the wheel will then tend to maintain the speed, and thus an approximation to uniform motion is obtained.

The machine consists of a strong frame, at the front of which is a

broad slide, moved vertically up and down by an eccentric fixed on the end of a shaft passing lengthwise through the frame: on this shaft there is a large wheel, which receives motion from a pinion on another shaft carrying the fly-wheel and driving-pulleys. The punches, the number of which varies according to the size of the holes, are fixed in the lower end of the vertical sliding piece, and immediately under them is fixed a piece of steel, called the dies, which has holes in it to correspond with the punches. The plate in which holes are to be punched is fastened upon a travelling table in front of the machine; and the slide being up, and the surface of the table level with that of the dies, the part where the holes are to be punched is placed between the punches and the dies, so that when the machine is set in motion, the punches are forced through the plate by the action of the eccentric, and the pieces driven out fall through the holes in the dies: after the punches have risen above the surface of the plate, the travelling table is set forward to the required distance by self-acting apparatus, and the operation is repeated by the machine till the required number of holes has been punched.

The plate-cutting apparatus consists of two steel plates, forming a pair of shears; the lower plate is fixed on the frame of the machine, and the upper one is attached to a slide, as in the case of the punches, acting in a similar manner. The shears are moved by the same shaft as the punches, and act while the punches are being raised: sometimes they are placed at the top of the punching slide.

Punt, in navigation, a sort of oblong, flat-bottomed, small boat, with a square head and stern

Purbeck-stone, an alkaline sandstone, harsh and rough, of a disagreeable ash colour, very heavy, and moderately hard; of a texture not very compact, but somewhat porous, and composed of an angular grit, cemented together by an earthy spar. It cuts freely, and with a tolerably even or smooth surface, but will not take a polish: it is used principally in London. The quarries are in the island of Purbeck, Dorsetshire.

Purlins, in carpentry, those pieces of timber that lie across the rafters on the inside, to keep them from sinking in the middle

Purple, the third and last of the secondary colours, is composed of red and blue, in the proportions of five of the former to eight of the latter, which constitutes a perfect purple, or one of such a hue as will neutralize and best contrast a perfect yellow in the proportion of thirteen to three of surface or intensity. It forms, when mixed with its co-secondary colour, green, the tertiary colour olive, and when mixed with the remaining secondary orange, it constitutes the tertiary colour russet.

Purple Black is a preparation of madder, of a deep purple hue, approaching to black; its tints, with white-lead, are of a purple colour. It is very transparent and powerful, glazes and dries well in oil, and is a durable and eligible pigment, belonging perhaps to the semi-neutral class of marrone.

Purple Lake. The best purple lake, so called, is prepared from cochineal, and is of a rich and powerful colour, inclined to crimson. Its character as a pigment is that of a cochineal lake, already described. It is fugitive both in glazing and tint, but, used in considerable body, as in the shadows of draperies, &c., it will last under favourable circumstances a long time. Lac lake resembles it in colour, and may supply its place more durably, although not perfectly so.

Purple Ochre, or Mineral Purple, is dark ochre, a native of the forest

Dean, in Gloucestershire. It is of a murrey or chocolate colour, and forms cool tints of a purple hue, with white. It is of a similar body and opacity, with darker colour than Indian red, which has also been classed among purples, but in all other respects it resembles that pigment. It may be prepared artificially, and some natural red ochres burn to this colour, which has been employed under the denomination of *violet de mar*.

Purple wood is from the Brazils, imported in logs from 8 to 12 inches square, and 8 to 10 feet long, principally used for ramrods, buhl-work, marquetry, and turnery

Purser, the cashier or paymaster of mines; also the paymaster of a ship

Pursuivant, in heraldry, a messenger who formerly attended the king in his wars, or at the council table, and ultimately became herald

Puteal, the enclosure surrounding the opening of a well, to protect persons from falling into it. It was either round or square, from 3 to 4 feet high. There is a round one in the British Museum, made of marble.

Putlogs or *Putlocks*, in building, are short pieces of timber about 7 feet long, used in building scaffolds. They lie at right angles to the wall, with one of their ends resting upon it, and the other upon the poles which lie parallel to the side of the wall of the building.

Putlog-holes, small holes left in walls for the use of the workmen in erecting scaffolding

Putty, in the arts, a kind of paste used by glaziers, composed of whiting and linseed oil (with or without white-lead), beaten together to the consistence of a tough dough

Puzzolano, or *Pouzzolano*, in mineralogy, a volcanic sand of a violet red colour, (the *pulvis Puteoli* of *Pliny*,) brought from Italy, which forms a cement that hardens under water. It appears to be a species of argillaceous earth that probably has been calcined and then ejected from a volcano. Its constituents are silex, alumina, oxide of iron, and a little lime. It was first dug out of the earth by the Romans near the town of Pouzzol, not far from Vesuvius. The environs of Rome furnish it equally. It has been found in France in the extinct volcanoes of Vivares. There are a few regions exposed to igneous agency which are destitute of it, but it presents itself under very different physical appearances, — sometimes pulverulent, sometimes in coarse grains, often in slag, pumice, tufa, &c. Its colour, which is generally brown, passes to yellow, gray, and black. The only preparation this material undergoes previous to use is that of pounding, or grinding and sifting, whereby it is reduced to powder, in which state it is beaten to a proper consistency with a due proportion of lime. Artificial pouzzolano is also much used, and is produced by pulverizing the clay, the psammite, or the arene, which is soluted, and the strewing a layer of it, about four-tenths of an inch, on a plate of iron, heated to a point between a cherry-red and forging heat. It is left till it be raised to the same degree, for a space of time which varies, for each kind of material, from five to twenty minutes. It must be continually stirred with a small rod, in order that the whole of the particles may be uniformly calcined.

Pycnostyle, that arrangement of Greek or Roman columns, in which the intercolumniations are equal to one diameter and a half of the lower part of the shaft

Pyramid, in geometry, is a solid figure whose base is a polygon, and whose sides are plain triangles, their several points meeting in one

Pyrites, in mineralogy, a name given to certain metallic ores contain-

ing a large portion of sulphur; native compounds of sulphur with different metals, and more especially with iron. The term is derived from the use to which the stone was formerly applied, that of obtaining sparks by percussion, an application of pyrites mentioned by Pliny.

Pyrites, Copper, in mineralogy, a combination (sulphuret) of copper and sulphur, being the most common ore of copper

Pyrites, Iron, in mineralogy, a combination (sulphuret) of iron and sulphur, one of the most abundant minerals in nature

Pyrometer, in chemistry, an instrument for measuring very high temperatures, depending on the uniform and permanent contraction of pure clay

Pyrometer, a contrivance for ascertaining the temperature of the flues of boilers, by fixing an iron wire at the back of the flue, and connecting it to a lever in front of the boiler, which indicates the degree of expansion and consequently the temperature

Pyx, Pix, a tabernacle or shrine, a depository for the Host, or consecrated wafer, used in Roman ceremonies. (See *Theoreca*.)

Pyx, in navigation, the box in which the nautical compass is suspended

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QUA

QUADRA, in architecture, a name given by Vitruvius to the square piece, commonly called the socle, used to support the pedestals of statues, vases, and other ornaments

Quadræ, the bands or fillets of the Ionic base, between which the scotia or hollow occurs; also the plinth, or lower members of the podium

Quadrangle, a figure having four angles and four sides

Quadrant, the fourth part of a circle, being bounded by two radii perpendicular to each other, and a quarter of the circumference, or 90 degrees

Quadrature, the finding a square equal in area to another figure

Quadrifores, folding-doors whose height was divided into two. Folding-doors which opened in one height were termed *fores valvatæ*, or *valvæ*. Vitruvius directed the doorways to be made wider when these were used, and the height to be increased when the folding-doors were divided in height. The *bifores* of Vitruvius were two single doors.

QUA

Quarry, a place underground from whence are taken marble, freestone, slate, limestone, and other stones proper for building and paving

Quarry, a pane or piece of glass cut in a lozenge or diamond form

Quarter, in heraldry: this word is sometimes used for an escutcheon or coat of arms: there are sixteen quarters required to prove nobility

Quarter (ship's), the after-part of the top-side

Quarters, in building, those slight upright pieces of timber placed between the puncheons and posts, used to lath upon. These are of two sorts, single and double: the single quarters are sawn to 4 inches thick and 4 inches broad; the double quarters are sawn to 4 inches square. It is a rule in carpentry that no quarters be placed at a greater distance than 14 inches.

Quarter-deck, in ship-building, the short upper deck from the aftermost end of the main chains to the stern

Quarter-gallery, the projecting convenience and ornament of the top side which is connected with the stern

Quarter-pieces, the carved figures at the aft-part of the quarter-gallery which joins to the taffrail, and forms the boundary of the stern

Quartering, in heraldry, the act of dividing a coat of arms into four or more quarters, by parting, couping, &c., by perpendicular and horizontal lines. The sovereign of Great Britain in the first quarter bears gules, the lions passant, *or*, &c.; in the second, formerly, azure, three fleurs-de-lis, &c.

Quatrefoil, an ornament of frequent occurrence in Gothic architecture, formed by a moulding disposed in four segments of circles

Quears, in mining, crevices in lodes

Queen-post, a vertical timber supporting the rafters of a trussed roof

Quercitron Lake, or *Quercitron Yellow*, is what its name implies. It is dark in substance, in grains of a glossy fracture, perfectly transparent, and when ground is of a beautiful yellow colour, more durable than the common yellow lakes, although not perfectly permanent.

Quick lime, such lime as is in the caustic or most active state, and which possesses the greatest power of operating upon different substances with which it may come in contact. It is quite the opposite in its qualities and properties to that which has fallen down into a powdery state, in consequence of being saturated with water and carbonic acid gas or fixed air, or which is slaked and become effete.

Quick-work, the short pieces between the ports withinside a ship

Quink, in building, a piece of ground taken out of any regular ground-plot or floor: thus, if the ground-plot be oblong or square, a piece taken out of a corner to make a court or yard, &c. is called a quink

Quirk, a small acute channel or recess, much used between mouldings in Gothic architecture: in Grecian architecture ovolos and ogees are usually quirked at the top, and sometimes in Roman

Quoins of stone, the corners of brick or stone walls: when they stand out beyond the brick-work, they are called 'rustic quoins'

RAB RAD

RABBET, that part of the keel, stern, and stern-post of a ship which is cut for the plank of the bottom to fit into; the edges of plank or deal for bulk-heads that are lapped one over the other, and wrought square, making each side of the bulk-head a smooth surface to the distance of two rooms and spaces

Rack, in mining, an inclined plane on which the ore and slime are washed and separated

Rack, a flat bar with teeth on one side, to work into those of a pinion

Racking, in mining, a process of separating small ores from the earthy particles by means of an inclined wooden frame: the impurities being washed off, the ore remaining near the head of the rock is taken from thence, and undergoes tossing

Radiant point, any point from which rays proceed

Radius, in geometry, the semi-diameter of a circle, or a right line drawn from the centre to the line of circumference; in anatomy, a bone of the fore-arm, which accompanies the ulna from the elbow to the wrist

Radius-rods, the guiding rods in a parallel motion, jointed to the connecting-links, to counteract the vibratory motion communicated by the beam, by guiding the links so that there is a point

Rafters, in carpentry, the secondary timbers of a house; the timbers let into the great beam

Rag-stone, in mineralogy. The Kentish rag-stone is a kind of lime-stone, much preferred to other stones of a similar nature: it is found in beds varying from 6 inches to 3 feet in thickness, and is composed of the following substances: carbonate of lime, with a little magnesia, 92·6; earthy matter, 6 5; oxide of iron, 0·5; carbonaceous matter, 0·4 = 100. This stone is now much used.

Rail or *life guards*, in locomotive engines, strong iron rods reaching down within about 2 inches of the rails, to catch and throw to one side any obstruction which may be on the rails

Rails, the moulding ornaments in the top-side, likewise in the head and stern of a ship

Railways, or roads in which tracks of iron or other smooth material are laid for the easy passage of wheel-carriages, appear to have been introduced between the years 1600 and 1650, in the neighbourhood of Newcastle, to facilitate the carriage of the coals from the pits, in 'waynes' or waggons, to the 'staythes' or discharging places on the Tyne. In 1676 they were described to be thus formed: "The manner of the carriage is by laying rails of timber from the colliery to the river, exactly straight and parallel; and bulky carts are made, with four rollers fitting those rails, whereby the carriage is so easy, that one horse will draw down four or five chaldrons of coals." These "rails of timber" were laid upon transverse timbers or sleepers, and secured with pegs of wood, the sleepers being embedded in the material of the roadway.

Before the year 1716, it became the practice to preserve the edges of the rails by nailing thin plates of malleable iron upon their upper surfaces in places where the draught was harder than usual. About the year 1767, cast-iron bars were substituted for the wooden rails, and this change is said to have been suggested by the wish of the iron-masters to keep their furnaces at work during a season of unusual depression in the market value of their manufactures. These iron bars were found too valuable to admit of a return to the wooden rails, and improvements of various kinds were introduced. Thus the rails were cast in the form of long narrow plates, with a vertical rim along one side (the transverse section resembling the form of the letter L), and thus the wheels of the waggons were retained in their places without the projecting rims or flanges which were required for wheels running on the plain rails or bars. These rails were called 'tram' or 'plate rails,' and thus distinguished from subsequent forms of iron rails which were introduced to dispense with the longitudinal timbers heretofore required beneath them, by casting the rails of sufficient depth to carry their load, and of reduced width, the flanged-wheels being returned to. Malleable-iron rails were introduced about the year 1815, at coal-works in Cumberland, with a view to remedy the defect of frequent breakage, to which those of cast iron were liable: these malleable-iron rails were simply bars of iron from 2 to 3 feet in length, and 1 to 2 inches square; but the narrowness of their surface was found to injure the wheels so severely, that the restoration of cast-iron rails appeared likely, when an ingenious invention was made by Mr. Birkinshaw, who obtained a patent in October, 1820, for his improvements, which consisted in passing bars of iron, red-hot, between rollers having indentations in their peripheries, corresponding with the intended shape of the rails. By this mode malleable-iron rails were rolled in lengths of 12 or 15 feet each, and could be formed in any required shape, the section varying

throughout the length, so as to give increased depth and width at the points intermediate between the intended bearing places. The rails now generally used are produced in a similar manner, and the permanent way consists of a levelled surface of roadway formed with metalling or suitable ballasting, transverse sleepers, commonly of larch, about 9 feet in length, 8 to 10 inches in width, and about 6 inches deep. These sleepers are laid from 2 feet 6 inches to 3 feet apart, and saddles or chairs of cast iron are fastened upon them with spikes. Two of these chairs are fixed upon each sleeper, at such distance apart that the rails, when placed in them, shall have the intended distance or *gauge* between them, commonly 4 feet 8½ inches. The rails are parallel throughout, and of a form resembling that of the letter ⌶ laid on one side, the depth of the rail being about 5 inches, the width over the top and bottom about 2½ inches, and the thickness of the middle vertical rib about ⅞ inch; all the angles of the section being carefully removed by rounding the meetings of the several surfaces. For the 'broad-gauge,' in which the rails are laid 7 feet apart, continuous longitudinal timbers, about 12 inches square, are employed, and connected by cross-timbers framed to them. The rails are of a bridged or arched section, and rolled with a projecting plate along each side, bolts passing through which secure the rails to the longitudinal timbers.

The theory of a perfect railway requires that it should be level in its vertical position and uniform in direction. Practically, these conditions are sacrificed within certain limits; but the attainment of great speed and safety, upon the present locomotive system, forbids any very wide extension of them. The consequence is, that great and expensive works are required in earthworks, bridges, viaducts, &c., to obtain the required inclination of surface and direction. The cost per mile at which the principal British railways have been constructed may be thus stated:

Arbroath and Forfar	£ 9,213
Chester and Birkenhead	34,198
Dublin and Drogheda	15,652
Dublin and Kingstown	59,122
Dundee and Arbroath	8,570
Durham and Sunderland	14,281
Eastern Counties & Northern and Eastern	46,355
Edinburgh and Glasgow	35,024
Glasgow, Paisley, and Ayr	20,607
Glasgow, Paisley, & Greenock	35,015
Grand Junction	22,293
Great North of England	26,855
Great Western	56,372
Hull and Selby	22,290
Liverpool and Manchester	50,923
London and Birmingham	52,882
London and Blackwall	288,177
London and Brighton	56,981
London and Croydon	80,400
London and Greenwich	266,322
London and South Western	27,874
Manchester and Birmingham	67,000
Manchester and Bolton	61,624
Manchester and Leeds	47,824
Midland and Bristol and Birmingham	35,402
Newcastle and Carlisle	13,370
Newcastle and Darlington	17,837
Newcastle and North Shields	44,233
North Union and Bolton and Preston	27,444
Preston and Wyre	22,261
Sheffield and Manchester	48,543
South Eastern	44,415
Taff Vale	19,597
Ulster	13,946
Yarmouth and Norwich	11,578
York and North Midland	23,066

The average *quantities* per mile of the several items required in the formation of a double line of railway, of the 4-ft. 8½-in. gauge, up to the completion of the permanent way, and exclusive of the stations and buildings, locomotive and carrying stock, may be computed as

follows: The average earth-works in 342 miles, comprised in ten completed railways, amount to 103,330 cubic yards per mile. Land required, 12 acres. Ballasting, 30 feet wide, 18 inches thick, 8800 cubic yards. Sleepers, 8 feet long, 10 × 5 inches, placed 2 feet 6 inches apart, 11,733 cubic feet, or 235 loads of timber, or 4224 sleepers. Rails in 15-feet lengths, 1408 lengths: weight, at 56 lbs. per yard, 176 tons. Chairs for joints of rails, 1408 in number, weighing, at 20 lbs. each, 12 tons, 11 cwts. 1 qr. 20 lbs.: intermediate chairs, 2 feet 6 inches apart, 7040 in number, weighing, at 15 lbs. each, 47 tons, 2 cwts. 3 qrs. 12 lbs. Oak trenails and iron spikes, 16,896 of each; with 8448 wooden keys for fixing the rails in the chairs. Felt, for chairs, in pieces 10 × 5 inches, 2933 square feet. Timber in side fences, posts 8 feet long, 6 × 4 inches, 9 feet apart; 4 rails, 5 × 2½ inches; intermediate stay, 3 × 2 inches: total, 110 loads.

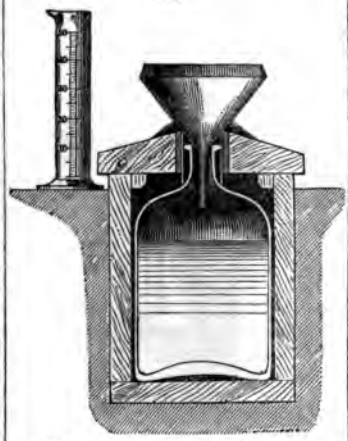
Of the quantity of masonry in bridges, viaducts, culverts, drains, retaining-walls, &c., an average of a few cases gives 110,000 cubic feet per mile.

Railway chairs, the pieces of cast iron which fix the rails to the sleepers

Rainbow, a meteor in the form of a party-coloured arch or semicircle exhibited in a rainy sky, opposite to the sun, and caused by the refraction of his rays in the drops of falling rain: it never appears greater than a semicircle, but often much less: it is always double, there being what is termed the superior and inferior, or primary and secondary rainbow: they always exhibit the seven prismatic colours; and the whole of this phenomenon depends upon the rays of the sun falling on spherical drops of water, and being in *their passage through* them *refracted and reflected*

Rain-gauge, an instrument for measuring the depth of rain that falls. A very simple and excellent instrument for this purpose is shown in fig. 1. It consists of a copper

Fig. 1.

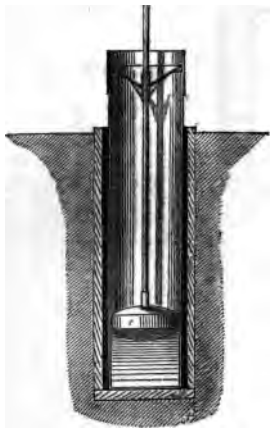


funnel, from 5 to 7 inches diameter. The rain being collected in a glass bottle, this bottle should be placed in a small stand near the surface of the ground, to protect the bottle from the action of the sun. The amount of rain fallen in a given time is measured in a graduated glass jar, one-tenth the area of the funnel, similar to that shown in the figure, and so divided that every inch in depth of the tube shall indicate one-tenth of an inch falling in the funnel. The amount of rain falling can be measured by such an instrument to $\frac{1}{5000}$th part of an inch, or even less.

An instrument, fig. 2, is also used for measuring the fall of rain. It consists of a cylinder of copper or other metal, from 5 to 7 inches in diameter, and 30 inches long. A float, just so much smaller as to allow it to rise freely when it becomes filled with water, is placed within the cylinder, and to the

centre of the float is attached an upright staff, marked in inches and tenths of an inch, which, rising through a hole at the bottom of

Fig. 2.



the funnel, as shown in the figure, indicates the depth of rain received into the gauge.

This instrument is very simple, and shows the amount of rain collected upon mere inspection: it has, however, been proved that in hilly districts and exposed situations, when the staff rises but a small distance above the receiving surface of the gauge, owing to the rain being carried along with the wind in a slanting, and frequently, on the tops of high hills, almost in a horizontal direction, that the staff, though of small diameter, arrests a large amount of rain, which runs down the staff and causes a much larger quantity to be collected than is properly due to the rain-fall. (Some interesting experiments, showing the incorrect results given by these rain-gauges, will be found in a 'Report on the Supply of Surplus Water to Manchester, Salford, and Stockport,' by S. C. Homersham, Civil Engineer.) When these kind of rain-gauges are used, the rod should be moveable, fitting loosely the socket or the float, and only placed in the gauge when the depth of the rain-fall is to be ascertained.

Rainline, a small rope, or line, sometimes used to form the sheer of a ship, and to set the beams of the deck fair

Rake, in mining, an oblique vein

Rake, in ship-building, an obtuse angle, such as the stem and stern-posts make with the keel of a ship

Rake of a ship, all that part of the hull which hangs over both ends of the keel

Raking moulding, in joinery, a moulding whose arrises are inclined to the horizon in any given angle

Ramp, in hand-railing, a concavity on the upper side, formed over risers, or over half or quarter span, by a sudden rise of the steps above, which frequently occasions a knee above the ramp

Rampant, in heraldry, a term applied to a lion, leopard, &c., standing on his hind legs, in the escutcheon, with his fore feet reared up in the posture of clawing

Rampant Arch, one whose abutments spring from an inclined plane

Ranges, pieces fixed to the inside of a ship to belay the ropes; and sometimes expressed for those between the ports whereon the shots lie

Rasp, a rough file

Ratchell, loose stones

Ratchet-brace, a tool for drilling a hole in a narrow plane where there is not sufficient room to use the common brace: a ratchet-wheel is fixed on the drill-socket, and turned by a handle with a strong spring attached to force round the socket on the forward motion, and slips over the teeth on the backward motion

Ratio is the relation of two quantities of the same kind with respect to quality, and is divided into arithmetical and geometrical

Ratlines, in ship-rigging, small lines that traverse the shrouds of a ship horizontally, at regular distances, and form ascending ladders to the mast-head

Rebate, a deep groove, or channel, cut longitudinally in a piece of timber to receive the edge of a plank, or the ends of a number of planks, which are to be securely fastened in it

Receiver of an air-pump, in pneumatics, a glass vessel placed on the top of a plate, out of which the air is exhausted by the pump

Recess, a cavity in a wall, left either for ornament or use when it is to receive some furniture, as a side-board, or to add to the quantity of room; and for ornament when made in the form of a niche, to give beauty and variety to the building

Reckoning, in navigation, the computation of a ship's way (usually by the log), or the act of estimating the distance run between one part and another

Reconciles, or *Top Timber-Hollow*, in ship-building, a mould sometimes used to form the hollow in the top-side, which is called the reconciling mould

Rectangle, a right angle made by the falling of one line perpendicularly upon another

Rectification, in chemistry, is the repetition of a distillation or a sublimation several times, in order to render the substance purer and finer, or freer from earthy and aqueous particles

Rectification, in geometry, is the finding of a right line equal to a proposed curve

Rectilineal, or *Rectilinear*, consisting of right lines

Rectory, a house for the residence of the rector of a parish, usually situated near the church

Red is the second and intermediate of the primary colours, standing between yellow and blue, and in like intermediate relation also to white and black, or light and shade. Hence it is pre-eminent among colours, as well as the most positive of all, forming with yellow the secondary orange and its near relatives, scarlet, &c.; and with blue the secondary purple and its allies, crimson, &c. It gives some degree of warmth to all colours, but most so to those which partake of yellow.

Red-lead, Minium, or *Saturnine red*, an ancient pigment, by some old writers confounded with cinnabar, and called Sinoper, or Synoper, is a deutoxide of lead, prepared by subjecting massicot to the heat of a furnace with an expanded surface and free accession of air. It is of a scarlet colour and fine hue, warmer than common vermillion; bright, but not so vivid as the biniodide of mercury, though it has the body and opacity of both these pigments, and has been confounded even in name with vermillion, with which it was formerly customary to mix it. When pure and alone, light does not affect its colour; but white-lead, or any oxide or preparation of that metal mixed with it, soon deprives it of colour, as acids do also; and impure air will blacken and ultimately metallize it.

Red Ochre is a name proper rather to a class than to an individual pigment, and comprehends Indian red, light red, Venetian red, scarlet ochre, Indian ochre, redding, ruddle, bole, as well as other absurd appellations, such as English vermillion, and Spanish brown, or majolica

Reef, in navigation, to contract a sail by tying up a portion of it to the yard

Refectory, a refreshment-room; the hall or apartment in a monastery

Refining and Puddling of Iron. The chemical difference between cast iron and wrought iron consists principally in the difference of degree in which foreign matters are

present in each, which is in larger amount in the former than in the latter. There are many cases in which wrought iron contains a larger amount of impurities than cast iron, and is yet malleable; while cast iron of the same composition may be very hard and brittle. Berzelius detected in a certain kind of bar iron, 18 per cent. of silex; and yet this iron was still malleable and useful. One-tenth of that amount of silex will make cast iron brittle. The foreign matters generally combined with pig iron are carbon, silicon, silex, sulphur, phosphorus, arsenic, zinc, manganese, titanium, chrome, aluminum, magnesium, and calcium. Each of these tends to make iron brittle; therefore, in converting cast into wrought iron, it is necessary, as far as possible, to remove them. Carbon and other foreign matters divide the crude iron into two very distinct classes. In the one, carbon is only an accidental mechanical admixture; in the other, it is in definite chemical combination. To the first belong the white iron of heavy burden, and gray iron; to the latter, the white iron of small burden, or very fusible ores. From the behaviour of the different metals in the refining and puddling process, the presence of silicon and silex appears to exert a similar influence: it is not possible to remove silex from white metal with which carbon is chemically combined. The silex is present in the form of silicon. White metal of small burden may contain from 5 to nearly 6 per cent. of carbon; and, if smelted from pure ore, almost an equal amount of other foreign matter, such as silicon. Upon the presence and form of these its white colour and crystallization in a degree depend. Gray pig iron seldom *contains* more than 4·75 per cent. *of carbon,* and generally only from *3·50 to 4* per cent. When carbon is present to the amount (to 3 per cent., it become The more this iron is st the more it forms fibres. bar iron resembles hickor in the fact that it is a coml of fibres and spaces. In l these spaces are filled with and that portion of the proportional to the finenes fibres. That portion of t which is not melted, whic tallizes too fast, or whose ture crystallization the w cannot prevent, is in the cc of cast metal, and cannot verted into fibrous wroug In the puddling furnace i cessary to prevent crystal by manual labour. This whether in the Catalan fo Woolf's oven, or the Germa is partly accomplished blast.

Reflection is the return or re motion of a moveable body from the reaction of som body on which it impinges

Reflex, in painting, denote parts of a picture that are si to be illuminated by a li flected from some other b presented in the piece

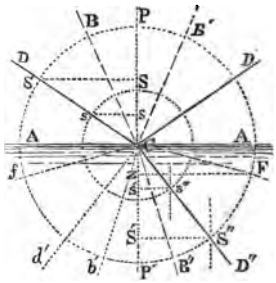
Reflux, in hydrography, the eb ward course of water, flux, or of the sea

Refraction, in mechanics, th vation or change of detern in the body moved. In di it is the variation of a light from that right line i it would have passed on, l the density of the medium it aside. It is the bending of light towards the perpe when it passes into a denser n and from the perpendicula it passes into a rarer mediu

The law of refraction w completely established by S Descartes at the commence the seventeenth century. T part of this law is similar of reflection, viz. that the

incidence and refraction (*i.e.* the angles which the incident and refracted ray each make with the perpendicular or normal of the surface, or in this case the angles P C D and P′ C D″) are both in the same plane. Any ray meeting the surface of a new medium is split into two rays, one reflected and the other refracted; as, for instance, the ray B C into the reflected ray C B′, and the refracted ray C B″; or D C into the two rays C D′ and C D″. So also a ray B″ C will be partly reflected in the direction C *b*′, and partly refracted into C B; or D″ C will be reflected into C *d*′, and refracted into C D. Now in all these cases the three rays, incident, reflected, and refracted, will be all in one plane, and that plane perpendicular to the acting surface A A.

The angles of incidence and reflexion (such as P C D and P C D′) are, as already explained, invariably equal; but that of refraction (in this case P′ C D″) is different from both, but connected with them by this law, that (at the same surface) the sines of incidence and refraction to the same radius bear a constant ratio to each other, which is always the same in the same two media.



For instance, in passing through the surface A A, at whatever degree of obliquity, and whether upwards *from the water into the air*, or down *from the air into the water*, a ray is invariably so bent that the angle it makes with the perpendicular P P′ in the air may be greater than that in the water; and that the sine of the angle in air may be to that in water (to the same radius) as 4 to 3, which is the ratio that has been determined by experiment. At the surface separating any other two media, a different ratio would be observed with equal constancy.

To find the new direction into which any ray, such as D C, will be bent by this surface, draw a circle round the point C with any radius, such as C S, and the sine of the ray in air (to this radius) will be found to be S S. Therefore the sine in water will be $\frac{3}{4}$ of S S. Draw a line parallel with C P at a distance therefrom equal to $\frac{3}{4}$ of S S, viz. at the distance S′ S″, and as this intersects the circle at S″, the refracted ray must pass through S″ to make its sine in water (S′ S″) $\frac{3}{4}$ of its sine in air (S S), both to the same radius (C S, or C S″). If any other radius be chosen, as C *s*, it is plain that the same result will be obtained; for, by the property of similar triangles, if S′ S″ be $\frac{3}{4}$ of S S, then *s*′ *s*″ is also $\frac{3}{4}$ of *s s*.

In tracing the course of a ray upwards from the water, as D″ C, then, having found its sine in water to any fixed radius, make its sine in air $\frac{1}{3}$ greater, because the sine in air is always greater than that in water, as 4 : 3; and thus the new direction of the ray will be found to be C D.

In this case a very singular effect takes place if the ray be very oblique to the surface, as F C. It should be remarked that no ray passing from the air into the water, however obliquely, could ever be refracted into the direction C F, for this reason, the sine of no angle can be greater than the radius to which it is drawn, therefore no ray can have its sine to radius C S greater than C S. But its sine in

water is only $\frac{3}{4}$ of that in air, and consequently cannot exceed $\frac{3}{4}$ of the radius. Now the sine of the ray C F, viz. F z, is more than $\frac{3}{4}$ of the radius C S, therefore no degree of obliquity of the ray in air will enable it to become so oblique in the water as C F. But a ray may ascend in the direction F C as well as in any other. Now its sine in air must become $\frac{1}{3}$ greater than F z; but this is impossible, for a line $\frac{1}{3}$ longer than F z would be longer than the radius C S, and therefore too long to be the sine of any angle to that radius. As this ray, then, cannot be refracted according to the law, it is not refracted at all, but totally reflected in the direction C f, the only known instance of total reflection, for none of the light can penetrate the surface A A, which is, in fact, absolutely opaque to this light. This phenomenon of total reflection may be seen by looking through the side of a tumbler containing water up to its surface, in some such direction as fC, when the surface will be seen to be opaque, and more reflective than any mirror, inasmuch as the images in it are perfectly equal in brightness to the objects themselves.

Now at the surface between any other two media, the ratio of the sines would be different; for though all surfaces reflect alike (as regards the direction of the ray), all do not refract alike. Suppose the ray passed from vacuum into water, the ratio would be rather greater than 3 : 4, namely 1 : 1·335. In passing from vacuum into air of the common density, the refraction would be much less, and consequently the sines much more nearly equal, viz. as 1 : 1·000294. Now if the sine in any medium be called 1, the corresponding sine *in vacuo* is called the index of refraction of that medium; and is specific for *each substance*, or as constant as *its density*, expansibility, specific *heat*, or any other measurable quality. Thus the refractive air of the common d 1·000294, that of water crown glass 1·52, of flint g

In the case above co of refraction from air in and *vice versâ*, the sines i in water are, strictly spe 1·335 : 1·000294; and gen sines on each side of an are inversely as the refra dices of the two media.

The refractive indices c many media have been and arranged in tables. density of any substance is or diminished, its refracti is increased or diminishe same ratio.

The application of the refraction accounts for deceptive effects seen in t sphere, and included u general term *mirage;* the miliar of which is the dist objects seen through a ri rent of hot air, which, smaller density, has a l fractive power than the sur cold air, and therefore b rays in various direction also plain that the rays heavenly bodies coming fr into our atmosphere mus fracted, and thus cause th whence they come to appe above their true place, as at d in the figure sees direction dC rather above place. This forms one sources of error to be all in all astronomical obse and tables are calculated f its amount, depending on ject's apparent altitude, state of the barometer a mometer. Owing to the v refractive power of air, this error is hardly sensi the object is high, but rapidly towards the horizo it becomes 33′, or rather n the sun's or moon's dia that these bodies may

clear of the horizon when they are really completely below it. As the density of the air diminishes gradually upwards, atmospheric refraction is not, like that which has been just considered, a sudden change of direction, but the ray actually describes a curve, being refracted more and more at every step; and this applies equally to the light from a distant terrestrial object which is either lower or higher than the eye, because it must pass through air of constantly increasing or diminishing density. This refraction has therefore to be allowed for in levelling, which is done by assuming that the light from a distant object comes to us in a line arched or curved upwards, the radius of which is about seven times that of the earth.

The application of these laws of Dioptrics has also led to the understanding of the mechanism of the eye, and hence to the imitation thereof by lenses, affording the remedies for its infirmities of long and short sight, and disclosing the wonders of the telescope and the microscope.

Regalia, in heraldry, ensigns of royalty; the apparatus used at a coronation

Regardant, in heraldry, signifies looking behind, as applied to a lion or any other beast

Regatta, the name of an aquatic spectacle consisting of gondola races, &c., exhibited at Venice

Reglet, a flat narrow moulding, employed to separate panels or other members; or to form knots, frets, and similar ornaments

Regula, a band below the tænia of the Doric epistylium, extending the width of the triglyph, and having six guttæ depending from it. It also signifies the space between two adjoining canals of the triglyphs.

Regular. In geometry, a regular body is solid whose surface is composed of regular and *equal figures*, and *whose solid angles* are all equal. *There are five sorts*: 1. A pyramid, comprehended under four equal and equilateral triangles: 2. A cube, whose surface is composed of six equal squares: 3. That which is bounded by eight equal and equilateral triangles: 4. That which is contained under twelve equal and equilateral pentagons: 5. A body consisting of twenty equal and equilateral triangles.

Regulator, in mechanics, that part of a machine which makes the motion equable

Regulator-cock, in locomotive engines, a cock placed to admit oil or tallow to lubricate the faces of the regulator

Regulator-cover, in locomotive engines, the outside cover, removeable when required to examine the regulator

Regulator-shaft and levers, in locomotive engines, the shaft and levers placed in front of the smoke-box when each cylinder has a separate regulator. A rod connected with the shaft leads to the foot-plate, where a handle is placed conveniently for use.

Regulator-valve, the valve in a steam-pipe of a locomotive engine, for regulating the supply of steam to the cylinders

Regulator-valve spindle, the spindle for moving the regulator-valve; being fixed to it at one end, the other end of the spindle passes through a stuffing-box joint over the fire-box, and has a handle fixed on the end to turn it

Relief-valve, a valve belonging to the feeding apparatus of a marine engine, through which the water escapes into the hot well when it is shut off from the boiler

Relieving tackle, in mechanics, the two strong tackles used to prevent a ship's overturning on the careen, and afterwards to assist in uprighting her

Repercussion, in mechanics, the act of drawing back; rebound

Replum, the panel of the impagis, or horizontal rails of a framed door

Repose, in painting, denotes certain parts in the composition of a picture which seem to tranquillize its aspect

Reredos, behind the back; the back of a fire-place; also an altar-piece, a screen, or partition wall

Respond, in Gothic architecture, a half-pillar or piece attached to a wall to support an arch, &c.

Rest, in a lathe, a piece of iron to hold the turning-tool upon, fixed at the end of a slide by a set-screw: the slide can be moved at right angles to the bar of the lathe, and the whole can be fixed at any part of the bed, between the centres

Reticulated work, a species of masonry or break-work, formed externally by small square stones or bricks, placed lozenge-wise, and presenting the appearance of net-work

Reticulation is the method of copying a painting or drawing by the help of square threads. An open frame is made similar to a straining frame, and the painting enclosed within it: a number of threads are then strained over at equal distances, like net-work, which are fastened to the frame by nails. The canvas, or paper, is likewise divided into an equal number of proportional squares, and whatever appears within the square threads in the painting is copied into the corresponding squares on the canvas or paper. The squares of the copy may bear any proportion to those of the original. Painters often adopt this method when they first execute a small design, from which their large and more finished work is copied.

Revels, or *Reveals*, the vertical retreating surface of an aperture, or the two vertical sides of the aperture, between the front of the wall and the windows or door frames, most commonly posited at right angles to the upright surface

Reversing gear, the apparatus for reversing the motion of a marine or locomotive engine, by changing the time of action of the slide-valve: the eccentric being in advance of the crank for the forward motion will, if turned to an equal distance behind the crank, produce a backward motion

Reversing handle and guide, the handle placed beside the foot-plate conveniently for use when required. The guide is a quadrant fixed to the foot-plate, notched for the end of the reversing handle for each variation of the expansion gear. To reverse the engine, the handle is removed to any notch past the centre of the guide on the opposite side in which it was before. Expansion is varied by moving the handle from one notch to another notch on the same side of the centre of the guide from which the engine is working. When the handle is on the centre notch, the engine is said to be *out of gear*.

Reversing lever, the lever connected to a crank on the reversing shaft by a rod, and placed at the side of the fire-box, between guide-plates with notches to keep it vertical, or in the forward or backward position

Reversing shaft, the shaft, with levers on it, connected with the eccentric-rods in the rocking-shaft class, but with the slide-valve rod in the expansion-gear class of engines. Both arrangements effect the object of moving the slide-valve so as to admit steam to the contrary side of the piston to which it had previously been admitted, and thus reverse its motion, and with it the motion of the engine also.

Reversing valve. (See *Air-valve*).

Rhomb, an oblique angled parallelogram; in geometry, a parallelogram or quadrangular figure having its four sides equal, and consisting of parallel lines, with two opposite angles acute and two obtuse

Rhomboidal, approaching the shape

of a rhomb: in geometry, used to signify an oblique-angled parallelogram

Rhumb, in navigation, a vertical circle of any given place, or the intersection of a part of such circle with the horizon. Rhumbs coincide with the points of the world or horizon, and are distinguished like those of the compass. A rhumb-line cuts all the meridians under the same angle.

Rib, in constructive architecture, a moulding on the interior of a vaulted roof

Rib, an arch formed of a piece of timber

Rib, a pillar of coal left as a support for the roof of a mine

Ribs, arch-formed timbers, for sustaining the plaster-work of a vault, or wood ceiling

Ribband, pieces of fir nailed to the timbers of a square body under which shores are fixed

Ribbing, the whole of the timber-work for sustaining a vaulted or coved ceiling

Riders, in ship-building, interior ribs, to strengthen and bind the parts of a ship together, being fayed upon the inside stuff, and bolted through all

Ridge, the upper angle of a roof: tiles called ridge-tiles are sometimes made very ornamental.

Rigger, a wheel with a flat or slightly curved rim, moved by a leather band

Right angle, in geometry, is that formed by a line falling perpendicularly on another, or that which subtends an arc of ninety degrees

Right line, in geometry, signifies the same as a straight line, opposed to curved or crooked

Ring, in geometry, an annulus

Ring-tail, in navigation, a quadrilateral sail, occasionally hoisted abaft the after-leech of the boom mainsails, to which the fore-leech is made to correspond

Rising-rod, a rod in a Cornish engine which rises by means of levers as the cataract piston descends, and lifts catches which release sectors, and allow weights to shut or open the steam, equilibrium, or exhaust valve

Rivets, short bolts of metal inserted in a hole at the juncture of two plates, and, after insertion, hammered broad at the ends, so as to keep the plates together. Mr. Wm. Fairbairn invented a riveting machine, which by the aid of steam performs the work rapidly and without noise.

Riveting Machine. The principle of action of the riveting machine is very similar to that of an ordinary punching machine. The work performed by it is usually done by manual labour, which occupies a much longer time, causes great noise, and is much more expensive and less efficient. The machine consists of two strong side-frames forming bearings for the fulcrum for a powerful lever which works between them, and is raised or lowered by a cam acting at the extremity. On one end of the cam-shaft is a large spur-wheel moved by a pinion on the driving-shaft, which has a very heavy fly-wheel fixed on it, to accumulate power and expend it during the action of the lever. The riveting tool is placed in a guide near the short end of the lever, and directly opposite the end of the tool is another, to form the heads fixed on a pillar called the riveting-block. The rivet being made to enter the holes, and placed between the riveting tool and the block, the machine is set in motion, and the cam raises the lever, which presses against the tool and instantly forms the rivet.

Roads are artificially-formed ways between distant places, and being among the first means of personal communication, their formation and treatment, as duties of the engineer, are of the highest importance. The efficiency of road-

making requires that the surface of the road shall be preserved in a durable condition, and adapted for the kind of traffic to be conducted upon it; and, therefore, the construction of the road, both as regards its superstratum or surface, and substructure, its dimensions and inclination, or declivity, are equally to be determined with reference to the particular kind of wear to which it will be subjected. Thus the weights that will pass over the road will make it necessary that it possess greater or less firmness and solidity, while the rigidity or hardness of its surface affects the power required for moving bodies, or the draught. The vertical inclination of the road has an influence upon the draught, and is also limited by the class of traffic. The old Roman roads, for instance, designed for the passage of animals only, were laid with inclinations of great steepness, and with reference only to the directness of their course. The use of wheel carriages imposes limits to the steepness which cannot be exceeded either with safety or with economy of power. The most improved form of road—the railway—restricts the steepness or inclination still further, the propelling power employed being found to become expensive in a rapid ratio in proportion to the departure of the surface on which it is exerted from a horizontal plane. The qualities of a good road are, solidity of structure,—hardness of surface,—levelness of inclination, and sufficiency of width for all its purposes. To insure the permanence of these qualities, the formation and the drainage of the road are required to be complete, while the several means to be adopted will be partly determined by the kind of materials at command. Experiments made to ascertain the force of traction on different kinds of roads, have shown that this force is nearly in exact proportion to the strength and hardness of the road. Thus the draught on a well-made pavement is half that upon a broken stone surface, or old flint road, and less than a quarter of the draught upon a gravel road. If the strength or solidity of the foundation be increased, the draught is reduced. Thus, if the broken stone road be laid upon a rough pavement foundation, the draught is reduced one-third, and a similar reduction is effected by laying a bottoming of concrete formed of cement and gravel. The external forces by which the motion of bodies upon roads is retarded, and the draught or power required consequently augmented, are collision, friction, gravity, and the atmosphere. Collision is occasioned by the hard protuberances and irregularities of surface of the road meeting the wheels, and thus diminishing the momentum of carriages. The resistance arising from collision is proportional directly to the load and the height of the obstacle to be surmounted, and inversely to the diameter of the wheels of the carriage in which the load is borne. Professor Leslie has defined the resistance which friction causes to consist "of the consumption of the moving force, or of the horse's labour, occasioned by the soft surface of the road, and the continually depressing of the spongy and elastic substrata of the road." From the formulæ which have been deduced upon the extent of this resistance, it is evident that it is caused by the wheels sinking into the ground, and is proportional directly to the load, and inversely to the width of the wheels. The resistance produced by gravity is evidently in proportion to the steepness of the road, being nothing on a perfectly horizontal plane, and augmenting as the inclination approaches the perpendicular. The force of the air in resisting the

motion of loads upon roads may be understood from the experiments which are given in Smeaton's Reports, and from which it appears, that upon a surface of one square foot this force equals 1 lb. when the velocity of the wind is at the rate of 15 miles per hour; and that this force becomes equal to 12 lbs. when the air moves at the rate of 50 miles an hour, constituting a storm.

In designing a road, a correct survey of the proposed line, with the exact relative levels of all parts of its present surface, is the first requisite, and upon this the engineer proceeds to consider the propriety of deviating in one direction or another, in order to attain better levels, or to equalize the earthworks, so that the quantity excavated in one part may suffice to embank an adjacent portion, and thus reduce the distances to which the soil must be removed. In determining the inclinations of the surface, facts proved by experience should be consulted, from which the rule may be inferred that an inclination of 1 in 35 is that which admits of horses moving with perfect safety in a fast trot. Valleys are required to be crossed by bridges and viaducts, or solid embankments and hills are excavated with cuttings or with tunnels to reduce the elevation to which it would otherwise be necessary to carry the road. Streams and rivers are also occasionally to be passed over, and thus the design and execution of an extended length of road frequently involves some of the grandest works of engineering art.

Road-making was a principle of employment ingeniously carried out by Napoleon in those countries mastered by his arms; he discovered one element of the mixing of the poorer population by the monopolies and greediness of the rich; his master mind saw clearly that he could not better secure his power than by employing the unfortunate and labouring poor. Road-making zealously occupied his mind: his name to this day, for this simple and important fact, is revered. In those towns on the Continent where a résumé existed of the antagonistic principle, it is obvious that pauperism may be staved off by the more wealthy lords of the soil, if they give employment to the poor; and such conduct on the part of Napoleon naturally produced a veneration for his name. These poor people desired no cold charity; they sought for sustenance by the means of useful labour; and one of these was road-making. Many of them cheerfully shouldered the musket for the man who had so cherished them. Among the great projects carried out may be mentioned the Simplon road, from Geneva to Milan, which cost the French Government seventeen millions of livres, about £650,000.

Roasting of Iron Ore is either to produce higher oxidation, or to expel injurious admixtures. In both cases, liberal access of atmospheric air is required. Ore to be roasted should be broken into pieces as small as those usually put into the blast-furnace. The kind of fuel required is wood, and small charcoal, turf or peat, or brown coal, may be used. There are many different forms of ovens used; all of them can be reduced to that of the blast-furnace or the lime-kiln. These ovens are commonly from twelve to eighteen feet high, and contain from fifty to one hundred tons of ore at one time.

Rocking-shaft, the shaft, with levers on it, which works the slide-valves in some steam engines. The eccentric-rod drops on to a stud fixed in one lever, and the links of the slide-valve rod are attached to the opposite lever on the same shaft. This mode of working the slide-valves was generally adopted be-

fore the introduction, by Mr. Stephenson, of the direct-action mode of working them.

Rod, or *pole*, a long measure of 16½ linear feet, or a square measure of 272¼ square feet

Roller, a solid cylinder of metal or wood, used for many purposes

Rolling Machine, an invention for making the brass mouldings in fenders, and the brass-work in grates

Rolling Mill, a mill for reducing masses of iron, copper, or other metals, to even parallel bars or thin plates. This is effected by passing the metal, whilst red-hot, between two cylindrical rollers of steel, put in motion by the mill, and so mounted in a strong metal frame that they cannot recede from each other.

Roll-moulding, a moulding used in early English architecture, resembling a roll

Roman Architecture, in its masonry, both in public and private buildings, was of far more durable character and more accurate workmanship in the earlier periods than at the decline of the empire. It began with uncemented blocks of stone, passed into the reticulated work of the Republic, thence into the travertine, and descended into a mixture of tufa and brick, and stucco facing. The polyhædral wall, or, as it is often named, the Cyclopean, is the oldest example of masonry in Italy; but this style of building has been used in town walls only.

Until about the middle of the last century, Roman architecture was regarded as the Antique and the Classical *par excellence*, and was supposed to exhibit the most refined taste and most perfect artistic propriety. The 'Orders,' as practised by the Romans, were the examples taken up and followed by the Italian masters at the period of the so-called Revival, and still continue to be followed, both in that country and in France, in preference to their Greek prototypes. Among ourselves, however, the Roman style has of late years fallen somewhat into discredit,—at least as far as the orders are concerned,—while some have even gone further, and have censured the style of the Romans as being comparatively rude and coarse in taste, and their system as being radically vicious and inconsistent. Such is the opinion of both Mr. Fergusson and Mr. Freeman; and the latter writer further thinks, that "if the mad desire of imitating Greece had never taken possession of the Roman mind," Rome might, by adhering to her own previous mode of construction with the arch and vault alone, have ultimately wrought out a well-organized style, greatly superior to what she actually did produce, and which he pronounces to be, although not without its merits, "absurd and inconsistent to the last degree." This almost unqualified depreciation errs, perhaps, nearly as much as exaggerated and implicit admiration had done previously.

Nothing, indeed, is to be said in favour of the treatment of the two Greek orders by the Romans; for, strange to say, so far from the Doric acquiring greater energy, or the Ionic greater luxuriance, at their hands, the one was emasculated, the other impoverished, and both of them rendered insipid and characterless. On the other hand, it is to the Romans that we are indebted for almost all that we know of the Corinthian order as a style; and it might, with far greater propriety, be termed the Roman than the Corinthian one; for they not only greatly affected it and stamped it as their own, but frequently treated it with singular gusto.

As to Roman architecture generally, it possesses mechanical advantages and powers of construction unknown to that of the Greeks, and, owing to the adoption of cir-

cular and other curved forms of plan, possesses also a degree of variety and piquancy, if not of highly refined beauty, that we miss in the other more polished and correct style. Faulty as the interior of the Pantheon is, in regard to many points of design, Greece could never show any thing similar, much less equal to it. The exterior, too, of the same edifice may be quoted as affording an instance of a correct application of a columnar order not introduced as mere decoration between arches, but applied as a portico both for actual use and for the sake of the general effect. If it be a mixed system, that of the Romans possesses this advantage: viz. it allows either arcading or colonnading to be employed as may best accord with circumstances, whether in different buildings or in different parts of one and the same edifice.

Perfect congruity and simplicity are not the only valuable qualities in architecture; for there is also a merit and a charm in complexity, when diverse, if not contradictory, elements of construction and design are combined into an harmonious whole; and the Romans appear to have been far more studious of impressiveness of *ensemble* than of purity of form and elegance of detail. Besides a degree of vastness never aimed at by the Greeks, sumptuousness and picturesqueness may be said to have been the predominant characteristics of their buildings,—at least, of all their principal monuments.

Surely, then, we are at liberty to admire Roman architecture for its better qualities, without either being blind to its faults and defects, or imitating them, as if they were inseparable from its merits. Certain it is, that in all matters of design and decoration, modern taste inclines infinitely more to that of the Romans than of the Greeks. Hardly, too, can we dispense with Roman taste and Roman ideas, unless we can dispense with the Italian style also: yet the latter style, or one founded upon it, must continue to be employed for our secular buildings, both public and private, mediæval architecture being wholly out of the question for buildings generally at the present day.

Roman balance, in mechanics, the steelyard or *statera Romana*

Romanesque Architecture, a name given to the style of architecture which prevailed after the decline of the Roman empire, from the reign of Constantine till the introduction of the pointed arch

Roman white is of the purest white colour, but differs from the blanc d'argent only in the warm flesh-colour of the external surface of the large square masses in which it is usually prepared

Rood, in surveying, the fourth part of an acre in square measure, or 1210 square yards; a rod; a pole; a measure of 16½ feet, in long measure

Rood, or *roode*, a cross; a crucifix or image of Christ on the cross, placed in a church. The holy rood anciently was elevated at the junction of the nave and choir, and faced the western entrance to a church.

Rood-loft, a gallery which was generally placed over the chancel screen in parish churches, and was an addition peculiar to the Church of Rome. The rood-loft or gallery had its real support from the tie-beams which connected it with the walls of the building; but in the Decorative construction it appeared to rest on a range of arches or mullions below. Rood-lofts are formed both of stone and wood.

Rood-tower, or *steeple*, a tower or steeple at the intersection of the nave and transept of a church

Roof, the part above the miner's head; that part of the strata lying immediately upon the coal

Roofs, or coverings to buildings, a

variously formed, both as to materials and construction, although certain essential qualifications are common to all of them. Thus, they are required to effectually exclude the weather, and at the same time impose the least possible weight upon the walls of the buildings over which they are erected; and another purpose which they should be designed to effect is that of aiding the walls in maintaining their position by acting as ties between them at their highest and least stable points. A roof consists mainly of two parts, viz. the framing or trussing, and the covering, the width of most buildings being too great to be spanned with any practicable covering without the support of framing beneath it. In order to avoid unnecessarily loading the walls, the entire roof should be constructed as light as possible consistent with safety and durability, and its several parts so disposed that the weight shall fall *vertically* only upon the walls, and have no tendency to force them asunder. In this respect, therefore, the framing of a roof is required to act entirely together as the supporter of the covering, and cannot be properly designed to act *laterally against* the walls as abutments. Provided this condition is secured, roofs may be formed so as to preserve a level upper surface, or a ridged surface, the adoption of the form depending upon the occasion which may or may not exist for using the exterior of the roof as a place of resort for persons or otherwise. Thus, in the East, and in warm climates, roofs are commonly made flat on the top; while in temperate regions, exposed to rains, they are usually ridged, the surface being unavailable, and the escape of water facilitated by this form.

Flat roofs are generally composed of timber framing, and covered with stone in large slabs, or with artificial cements, or with concrete moulded in rectangular blocks. The timber framing in these roofs consists of main beams which span the roof from wall to wall in one direction, and of rafters of smaller scantling laid transversely to the beams, and notched down upon them; the distance between the rafters being determined by the size of the covering blocks or slabs.

Ridged roofs are composed of framings of wood, malleable iron, or cast iron, and coverings of tiles of burnt clay in various forms, of slate, of iron in rolled sheets or cast plates, of copper or lead in sheets. Each frame of the roof is termed a *truss*, and consists of several members, according to the width of the truss or span of the roof. The principal of these members, in a wooden truss, are, the *tie-beam*, which equals in length the span of the roof, and is laid horizontally across the building, resting at each end upon a wall-plate of timber, a cast-iron shoe, or a stone template;—the *principal rafters*, which are two timbers of equal length, framed into the ends of the tie-beam, and meeting, in the manner of the legs of an isosceles triangle, in a point equidistant from the ends of the tie-beam and at some height above its central point. The apex of the triangle or ridge of the roof is supported by a vertical post, called the *king-post*, properly framed and secured to the heads of the rafters and to the tie-beam. The two triangular spaces thus formed between the rafters, tie-beam, and king-post are filled in with other members, according to the size of the truss, and adapted to assist the rafters in bearing the weight of the covering, and to connect each rafter with the half of the tie-beam below it in a firm and substantial manner. In roofs of small span, these additional members are sim-

ply two *struts* fixed in a diagonal position from the bottom of the king-post on either side to the middle of the length of each rafter. In larger roofs the requisite strength is attained, and a space saved in the roof (available as a dormitory or store-room), by introducing two vertical posts, termed *queen-posts*, leaving a space in the centre of the roof between them, these queen-posts being secured by straps below to the tie-beam, and bearing the rafters above. A horizontal beam connects the heads of the queen-posts, and is termed a *collar-beam*, the centre of which is secured to a king-post, which supports the heads of the principal rafters and the ridge of the roof. Diagonal struts are framed in between the rafters and the king-posts and queen-posts, and thus complete the truss. The trusses are fixed at intervals, from 7 to 12 feet apart, throughout the length of the roof, and upon their principal rafters longitudinal timbers, called *purlins*, are notched down, and carry the *common rafters*, which are of minor scantling, fixed parallel to the principal rafters, at small distances apart. According to the kind of covering to be used, thin strips of wood, called *battens*, are secured to the common rafters, and upon these the slates, tiles, &c. are secured with pegs, or copper nails.

Iron roofs, which are much superior to those of timber, especially for large spans, from their lightness and resistance to fire, are composed of the same essential members as those here described, malleable rods or flat bars being substituted for the tie-beams and king-posts, and the rafters and struts made of sufficient stiffness with bars of malleable L or T-iron, or with cast iron of suitable form and section. In these roofs all the meeting-points of the several parts of each truss or principal are provided with cast-iron shoes, sockets, and connecting-plates, into which the ends of the rafters, struts, and rods are secured with screwed bolts and nuts, or gibs and keys.

Room and space, the distance from the joint or moulding edge of one floor timber to the other, which, in all ships that have ports, should be so disposed that the scantling of the timber of each side of the port, and the breadth of the port fore and aft (the openings between the timbers of the frames, if any, included), be answerable

Root, in arithmetic and algebra, denotes a quantity which, being multiplied by itself, produces some higher power

Rope, twisted hemp or wire, used in all kinds of buildings, for the management and control of building, for the construction of bridges, and on board ship; it is a species of tackle inseparable from the arts

Rope Machinery. The simple and beautiful contrivance employed in the dockyards for this most useful material, is contrived by machinery for the spinning of hemp into yarns, and the final preparation of the same into ropes and cables for the navy. The process first employed is separating the fibres from the hemp, and disposing them as nearly as possible into parallel juxtaposition; then the conversion of these bundles of parallel fibres into a flattened ribband-like form called a sliver, and the spinning of this sliver into a yarn, or simple twist. In a valuable treatise in vol. v. of the 'Papers of the Royal Engigineers,' will be found illustrative plates of the machinery employed in this operation in Deptford dockyard, together with an elaborate description.

Rosary, an office in the Church of Rome made up of five or fifteen tens of beads, each ten beginning with a Pater-noster, to direct them to say so many Ave Maria's in honour of the Virgin Mary

Rose Pink is a coarse kind of lake, produced by the dyeing of chalk or whiting with a decoction of Brazil wood, &c. It is a pigment much used by paper-stainers and in the commonest distemper paintings, &c., but too perishable to merit the attention of artists.

Rosetta wood is a good-sized East Indian wood, imported in logs, 9 to 14 inches diameter; it is handsomely veined. The general colour is a lively red orange. The wood is close, hard, and very beautiful when first cut, but soon gets darker.

Rose window, a circular window

Rose-wood is produced in the Brazils, the Canary Isles, the East Indies, and Africa. It is imported in very large slabs, or the halves of trees, that average 18 inches wide. The colours of rose-wood are from light hazel to deep purple, or nearly black; the tints are sometimes abruptly contrasted, at other times striped or nearly uniform. It is very heavy, and most abundantly used for cabinet furniture: large quantities are frequently cut for use in veneers.

Rostrum, the elevated platform or stage in the forum of ancient Rome, from which the orators addressed the people: a platform in a hall or assembly

Rotary motion, the rotation or motion of any body round an axis or centre: the velocity of this motion of bodies is proportional to their distance from such centre

Rotunda, in architecture, an appellation given to any building that is round both within and without side, whether it be a church, saloon, theatre, &c. The rotunda at Rome, called the Pantheon, and the chapel of the Escurial, the burying-place of Spanish royalty, &c., are of this form.

Rouge. The rouge végétale of the French is a species of carmine prepared from safflow, of exquisite beauty and great cost. Its principal uses consist in dyeing silks of rose colours, and in combining with levigated talc to form the paint of the toilette, or cosmetic colours employed by the fair.

Roughcast, in building, a kind of plaster mixed with pebbles, and consequently rough on the surface

Roundhouse, the uppermost deck in a ship abaft, sometimes called the poop

Royal Blue is a deep-coloured and beautiful smalt, and is also a vitreous pigment, principally used in painting on glass and enamelling, in which uses it is very permanent; but in water and oil its beauty soon decays, as is no uncommon case with other vitrified pigments: it is not in other respects an eligible pigment, being, notwithstanding its beautiful appearance, very inferior to other cobalt blues.

Rubble, coarse walling constructed of rough stones, small, irregular in size and shape; a mixture, or the refuse of several kinds of building-stone used for walls exteriorly, or between walls, to fill up

Rubens' Brown. The pigment still in use in the Netherlands under this appellation is an earth of a lighter colour and more ochreous texture than the Vandyke brown of the London shops; it is also of a warmer or more tawny hue than the latter pigment, and is a beautiful and durable brown, which works well both in water and oil, and much resembles the brown used by Teniers.

Rubric, or *Madder Lakes*. These pigments are of various colours, and are known by the various names of rose, rubiate, rose madder, pink madder, and Field's lakes.

Rudder, the principal matter which guides the ship. The main-piece and the bearding-piece are always oak, and the rest generally fir. The rudder should be bearded from the side of the pintles, and the fore-side made to the form of the pintles; but when they are bearded to a

sharp edge at the middle line, which is the customary way, it reduces the main-piece more than is necessary, which is easily perceived in large ships; for when the rudder is braced over, the bearding will not lie close to the sternpost by nearly ¾ of an inch.

Rudder irons, or *pintles*, the irons which are fastened to the rudder in order to hang it up to the sternpost: sometimes there are two of them cut short to work in a socket in the brace, which makes the rudder work easier

Rudenture, in architecture, the figure of a rope or staff, sometimes plain, sometimes carved, with which the third part of the flutings of columns are frequently filled up

Ruderation, in building, a term used by Vitruvius for laying of pavement with pebbles. To perform the ruderation it is necessary that the ground be well beaten, to make it firm, and to prevent it from cracking; then a stratum of little stones is laid, to be afterwards bound together with mortar made of lime and sand: if the sand be new, its proportion may be to the lime as three to one; if dug out of old pavements or from walls, as five to two.

Running-rigging, in navigation, denotes all that portion of a ship's rigging which passes through the blocks, to dilate, contract, or traverse the sails

Russet, *Rubiate*, *Madder Brown*, or *Field's Russet*, is, a sits names indicate, prepared from the *rubia tinctoria*, or madder root. It is of a pure, rich, transparent, and deep russet colour, of a true middle hue between orange and purple, not subject to change by the action of light, impure air, time, or mixture of other pigments. It has supplied a great desideratum, and is indispensable in water-colour painting, both as a local and auxiliary colour, in compounding and producing with yellow the glowing hues of autumnal foliage, &c., and with blue the beautiful and endless variety of aërial grays.

Rustication, the general name for that species of masonry in which the several courses of the stones in each course are distinctly marked by sunk joints or grooves, either chamfered or otherwise cut. Rustication admits of great variety of treatment, consequently of expression also; for, quite contrary to what its name literally imports, it is frequently made to show the very reverse of careless rudeness, namely, studied ornamentation, by means of highly finished moulded joints, &c.; and even when the faces of the rustics or stones are *vermiculated*, or otherwise made rough, it is left to be seen that it is done purposely or artificially, more especially when the vermiculation, &c., is made to show a sort of panel surrounded by a smooth border.

SAC

SACELLUM, a monumental chapel within a church

Sacrarium, a small family chapel in a Roman house; a place for the deposit of any thing sacred

Sacristy, a room attached to a church, where the sacred vestments and the utensils belonging to the altars were placed; termed also the sextry, the vestry, &c.

SAF

Saddle, in ship-building, a piece fitted on the upper end of the lacing

Safety-lamp, a wire-gauze lamp, constructed for the purpose of giving light in mines where fire-damp prevails

Safety-plug, in locomotive engines, a bolt having the centre filled with a fusible metal. It is screwed into the top of the fire-box, that the

metal may melt out by the increased temperature when the water becomes too low, and thus admit the water to put the fire out, and save the tubes and fire-box. When the water is allowed to fall below a proper height, there is great risk of spoiling both the fire-box and tubes by the intense action of the fire. This is called 'burning them;' and tubes subjected to such a trial are unfit for use again, as the tenacity of the metal has been destroyed.

Safety-valves, in locomotive engines, two valves placed on the boiler for the escape of steam when it exceeds the pressure limited by the load on these valves. One of them is placed beyond the control of the engine-man, and is usually called the *lock-up valve*. The other is regulated by a lever and spring-balance, at a little lower pressure than the lock-up valve. The apertures for safety-valves require no nice calculation. It is only necessary to have the aperture sufficient to let the steam off from the boiler as fast as it is generated, when the engine is not at work. The safety-valve is loaded sometimes by putting a heavy weight upon it, and sometimes by means of a lever with a weight to move along to suit the required pressure.

Safety-valve lever, in locomotive engines, the lever fixed at one end to a stud, and resting on the valve at a short distance from this stud. Its length is proportioned to the area of the valve, so that the spring-balance may indicate accurately the pressure in lbs. per square inch on the boiler, above the atmosphere.

Sagging, in ship-building, a term the reverse of *hogging*, being applied to the hull of a ship when the middle part of her keel and bottom arch downwards

Sagitta, in architecture, a name sometimes used for the key-piece of an arch

Sailing, plain, in navigation, is that which is performed by means of a plane chart, in which the parallels of latitude and longitude are every where equal

Saints' bell, a small bell used in the Roman Catholic worship, to call attention to the more solemn parts of the service

Salt-cellars, in Tudor times, were pieces on which the taste and fancy of goldsmiths were severely exercised. These artists were held in high estimation, and ranked with architects and sculptors. Benvenuto Cellini, in the time of Henry VII., was the greatest designer and chaser, or sculptor in gold and silver, in Europe: he visited England at this period, and excited much attention.

Sanctum Sanctorum, or holy of holies, the most sacred part of the temple of Jerusalem, containing the ark of the covenant

Sanctuary, the presbytery or eastern part of the choir of a church in which the altar is placed

Sand is the term applied to any mineral substance in a granular state, where the grain is of an appreciable size, and insoluble in water. It is more particularly denominated from the prevailing substance, as silicious sand, iron sand, &c. Sand is of general use for the mixing of material in building: river sand is far preferable.

Sand-boxes, in locomotive engines, boxes filled with sand, usually placed near the driving wheels, with a pipe to guide the sand to the rails, to be used when slipping takes place

Sand-stone, a soft porous kind of stone, generally known by the name of free-stone. It is composed of small particles of quartz in rounded grains, united by an argillaceous or calcareous cement.

Sandal wood, a tree having somewhat the appearance of a large myrtle. The wood is extensively employed as a perfume in the funereal ceremonies of the Hindoos. The deeper

the colour, which is of a yellow brown, and the nearer the root, the better is the perfume. It is imported in trimmed logs from 3 to 8, and rarely 14 inches in diameter, and the wood is in general softer than box-wood, and easy to cut: it is used for parts of cabinets, necklaces, ornaments, and fans.

Sanitary Precautions, for London in its southern district, were discussed nearly half a century since. Ralph Dodds, an eminent engineer of that period, writes, in his exhortation for a better supply of pure water, the following. "I cannot help noticing that part of the south metropolis, St. George's Fields, lies 4 or 5 feet below the flow of high water, and is so badly drained, and I may say, so saturated with filthy water, with other deposits of every species of dirt and filth from the City and Southwark, that it must be the first place to invite pestilence, should it ever be generated in this part of the country. I hope this will meet the eye of those who wait only for information to improve its situation."

Sapan wood, or *buckum wood*, is a middle-sized tree, indigenous to Siam, Pigu, &c.: for purposes of dyeing it is inferior

Sap-green, or *Verde Vessie*, is a vegetable pigment prepared from the juice of the berries of the buckthorn, the green leaves of the wood, the blue flowers of the iris, &c.: it is usually preserved in bladders, and is thence sometimes called bladder green; when good, it is of a dark colour and glossy fracture, extremely transparent, and of a fine natural green colour. Though much employed as a water colour without gum, which it contains naturally, it is a very imperfect pigment, disposed to attract the moisture of the atmosphere and to mildew; and having little durability in water-colour painting, and less in oil, it is not eligible in the one, and totally useless in the other.

Sapphire, a pellucid gem, which in its finest state is extremely beautiful and valuable, and inferior only to the diamond in lustre, hardness, and value. Its proper colour is pure blue; in the finest specimens it is of the deepest azure, and in others it varies into paleness, in shades of all degrees between that of a pure crystal brightness and water without the least tinge of colour, but with a lustre much superior to the crystal. The gem known to us by this name differs greatly from the sapphire of the ancients, which was only a semi-opaque stone of a deep blue, veined with white, and spotted with small gold-coloured spangles in the form of stars.

Saracenic Architecture is a species of architecture derived by the Europeans from the Arabs, or Saracens, during the crusades

Sarcophagus, a stone coffin or grave in which the ancients laid those they had not a mind to burn

Sash, a chequred frame for holding the squares of glass in windows, and so formed as to be let up and down by means of pulleys inserted, or other contrivances. The ordinary sashes are either single or double hung.

Sassafras wood is a species of laurel, and the root is used in medicine: it measures from 4 to 12 inches in diameter. It is sometimes used for cabinet-work and turnery.

Satin wood. The best variety is the West Indian, imported from St. Domingo both in square logs and planks, from 9 to 20 inches wide. The next in quality is the East Indian, logs from 9 to 30 inches diameter. The wood is close, not so hard as box-wood, but somewhat like it in colour, or rather more orange; some pieces are very beautifully mottled and curled. It is much used for internal decorations and furniture. It is also used for many other purposes for its light and agreeable tone.

Saucers, small deep dishes, for sauces,

&c., and also used as stands for vases, and other vessels filled with wines, to prevent the liquor being spilt upon the table. In the reign of Elizabeth, dishes and platters, which before her time were quite flat, began to assume their present form.

Saul or *Sâl*, an East Indian timber-tree. This wood is in very general use in India for beams, rafters, and various building purposes; is close-grained and heavy, of a light brown colour, not so durable but stronger than teak, and is one of the best timber-trees of India.

Saunders' Blue (a name corrupted from *cendres-bleu*), the original denomination probably of ultramarine ashes, is of two kinds, the natural and the artificial. The artificial is a verditer, prepared by lime or an alkali, from nitrate or sulphate of copper. The natural is a blue mineral, found near copper mines, and is the same as mountain-blue.

Saw, a toothed instrument which serves to cut into pieces several solid matters, as wood, stone, ivory, &c. The best saws are of tempered steel, ground bright and smooth; those of iron are hammer-hardened: hence the first, besides their being stiffer, are likewise found smoother than the last. They are known to be well hammered by the stiff bending of the blade, and to be well and evenly ground by their bending equally in a bow. The edge in which are the teeth is always thinner than the back, because the back is to follow the edge. The teeth are cut and sharpened with a triangular file, the blade of the saw being first fixed in a whetting-block.

Saw file, a triangular file for sharpening a saw

Saw Mills. The very ingenious machinery constructed by the late Mr. Henry Maudslay is employed in the dockyards to saw timber, and for cutting deals and the several *kinds* of timber used in the navy and in public works, into the several scantlings, sizes, forms, or shapes. In vol. vi. of the 'Papers of the Royal Engineers' will be found a most ample statement of the processes for sawing, and cutting, and hoisting, by steam power, in Chatham dock, together with engravings illustrative of every operation in these works.

Saxon Style of Architecture. This is easily recognized by its massive columns and semicircular arches, which usually spring from capitals without the intervention of the entablature. In the first Saxon buildings, the mouldings were extremely simple, the greater part consisting of fillets and plat-bands, at right angles to each other, and to the general surface. The archivolts and imposts were similar to those found in Roman edifices. The general plans and disposition of the latter Saxon churches were as follow: the chief entrance was at the west end into the nave, at the upper end of which was a cross, with the arms of it extending north and south; the east end, containing the choir, terminated in a semicircular form. A tower was erected over the centre of the cross, and to contain the bells another was frequently added, and sometimes two. The large churches contained a nave and two side aisles, one on each side of the nave, and were divided into three tiers or stories, the lower consisting of a range of arcades on each side, the middle a range of galleries between the roof and vaulting of the aisles, and the uppermost a range of windows. The pillars were either square, polygonal, or circular. Such was the thickness of the walls and pillars, that buttresses were not necessary, neither were they in use. The apertures were splayed from the mullions on both sides. The dressings are generally placed on the sides of the splayed jambs and heads of the

arches, and but seldom against the face of the walls; and when this is the case, the projectures are not very prominent. The dressings of the jambs frequently consist of one or several engaged columns upon each side. The imposts, particularly those of the windows, have frequently the appearance of being a part of the wall itself. The doors in general were formed in deep recession, and a series of equidistant engaged columns placed upon each jamb, and were such, that two horizontal straight lines would pass through the axis of each series, and would, if produced, terminate in a point. Each column is attached to a recess formed by two planes, constituting an interior right angle. The angle at the meeting of every two of these recesses formed an exterior right angle, which was sometimes obtunded, and frequently hollowed. The archivolts, resting on the capitals of the columns, are formed on the soffit shelving, like the jambs below. The ornaments of columns and mouldings are of very simple forms. The rudely sculptured figures, which often occur in door cases, when the head of the door itself is square, indicates a Roman original, and are mostly referable to an era immediately preceding the Conquest.

Scabellum, in ancient architecture, a kind of pedestal, commonly terminating in a sort of sheath or scabbard, used to support busts, &c.

Scagliola, in the arts, a composition, an imitation of marble, laid on brick in the manner of stucco, and worked off with iron tools

Scala, a ladder, a staircase, from Scala Santa, a building at Rome, erected from the designs of Fontana, with three flights of stairs. The building is so called because the middle flight consists of twenty-eight steps, said to have been passed over by *our Saviour in his progress to the house of Pilate.* They were sent from Jerusalem to Rome by St. Helena, and are objects of reverence to Roman Catholic pilgrims.

Scale, in painting, a figure subdivided by lines like a ladder, which is used to measure proportions between pictures and the things represented

Scamillus, a small plinth below the bases of Ionic and Corinthian columns

Scantling, the transverse dimensions of a piece of timber in breadth and thickness

Scantling is also the name of a piece of timber, as of quartering for a partition, or the rafters, purlin, or pole-plate of a roof. All quartering under five inches is termed scantling.

Scantling, in masonry, the size of the stones in length, breadth, and thickness

Scapple: to scapple a stone is to reduce it to a straight surface without working it smooth

Scarcement, a plain flat set off in a wall

Scapus, in architecture, the shaft of a column. In botany, a flower-stalk springing straight from the root, as in the primrose, snow-drop, &c.

Scarf, to lap the ends of plank or timber one over the other, to appear as one solid piece, as keel-pieces, clamps, &c.

Scarfed, in carpentry, signifies pieced or joined, being a particular method of uniting two pieces of timber by their extremities

Scarfing, the junction of two pieces of timber by being bolted or nailed transversely together, so that the two appear as one

Scarlet Lake is prepared in form of drops from cochineal, and is of a beautiful transparent red colour and excellent body, working well both in water and oil, though, like other lakes, it dries slowly. Strong light discolours and destroys it, both in water and oil; and its tints with white lead, and its combinations with other pigments, are

not permanent; yet when well prepared and judiciously used in sufficient body, and kept from strong light, it has been known to last many years; but it ought never to be employed in glazing, nor at all in performances that aim at high reputation and durability.

Scarp, in heraldry, signifies the scarf worn by military commanders

Scena, the permanent architectural front which faced the audience part of a Roman theatre: it sometimes consisted of three several ranges of columns one above another

Scenography, in perspective, the representation of a body on a perspective plane; a descriptionthereof in all its dimensions, such as it appears to the eye

Schola, the margin or platform surrounding a bath. It was occupied by those who waited until the bath was cleared. The schola was also a portico corresponding to the exedra of the Greek palæstra, and was intended for the accommodation of the learned, who were accustomed to assemble and converse there.

Schools of Painting. A school in the fine arts denominates a class of artists who have learned their art from a certain master, either by receiving his instruction or by studying his works, and who of consequence discover more or less of his manner from the desire of imitation, or from the habit of adopting his principles. All the painters which Europe has produced since the renovation of the arts are classed under the following Schools: the School of Florence, the School of Rome, the School of Venice, the Lombard School, the French School, the German School, the Flemish School, the Dutch School, the Spanish, and the English School.

Schooner, in navigation, a small two-*masted* vessel whose mainsail and *foresail* are suspended from gaffs *and* stretched out below by booms

Schweinfurt Blue appears to same in substance as Sc green, prepared without he treated with an alkali. It is a tiful colour, liable to the changes and is of the same as blue verditer, and the ab eligible pigment.

Sciography, in architecture, th file or section of a buildi show the inside thereof. In nomy, the art of finding th of the day or night by the s of the sun, moon, or stars.

Sconce, in manufactures, a candlestick, generally with a to reflect the light

Scotia, the hollow moulding base of an Ionic column, d from the Greek, signifying because, from being hollow, it is always in shadow. The is likewise a groove or cham in the projecting angle of the corona.

Scovanlode, a lode having no on its back or near the surfa

Scraper, a piece of iron used t out the pulverized matter remains in a hole when bore vious to blasting

Screen, a moveable frame-w keep off an excess of light, o or cold; a separation; a pa In ecclesiastical architect screen denotes a partition of wood, or metal; usually so in a church as to shut out a from the choir. a private from the transept, the nav the choir, the high altar fro east end of the building Some very beautiful example of screens, especially of tho parating the choir from the That of York is of a magn character. 'All Saints' C Maidstone,' a work publis 4to, is of an interesting desc on this head. In modern ar ture, a single open colonnad mitting a view through it, is a screen of columns: such w formerly in front of Carlto

Grosvenor House has a Doric screen in front of it

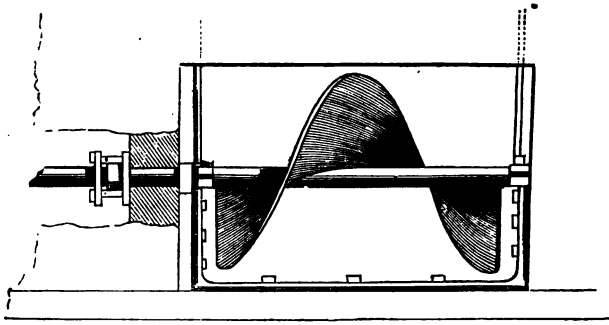
Screen bulk-head, in ship-building, that which is under the roundhouse

Screw, a spiral groove or thread winding round a cylinder so as to cut all the lines drawn on its surface parallel to its axis at the same angle. The spiral may be either on the convex or concave surface of the cylinder, and it is called accordingly either the screw or the nut. The screw can hardly be called a simple machine, because it is never used without a lever or winch to move it home, and then it becomes an engine of amazing power and utility in pressing together substances that have little cohesion, or in raising to short heights ponderous bodies. The smith, the carpenter, the printer, and the packer, all use screws in their respective occupations. Bales of wool, cotton, hay, &c., may be compressed by means of a screw into packages, the specific gravity of which shall be much heavier than an equal volume of water. Such packages will then sink in the ocean like a cannon-shot. Moreover, many of our domestic operations are performed by means of presses or screws; as the making of sugar, oil, and wine. The screw possesses one great advantage over the inclined plane, from which its principal of action may be said to be derived. The great attrition or friction which takes place in the screw is useful by retaining it in any state to which it has once been brought, and continuing the effect after the power is removed. It is thus the cabinet-maker's cramp, the smith's vice, and all those instruments made by mathematical instrument-makers in which screws act, can be employed with certainty. Screws are made with threads of various forms: some have sharp, others square or round threads.

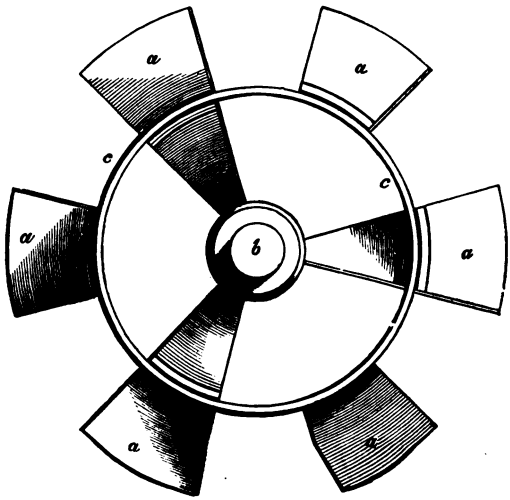
Screw-jack, a strong screw for lifting or supporting a heavy weight: it rests, by means of a large nut, upon a hollow base or pedestal, and is raised or lowered by turning the nut.

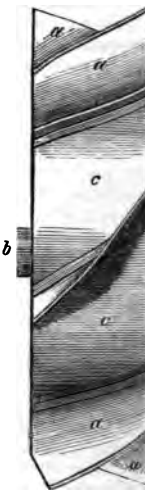
Screw. Screw propellers, for navigation, by means of steam power, have now become objects of importance to all nations, more particularly for those who navigate the broad waters: they are especially applicable for vessels of war, the machinery for propulsion being without the reach of shot. Screw propellers, however variously they may be modified, all derive their power of propelling by being placed on an axis which is parallel to the keel, and by having threads or blades extending from the axis, which form segments of a helix or spiral, so that, by causing the axis to revolve, the threads worm their way through the water, much in the same way as a carpenter's screw inserts itself into a piece of wood. There is, however, considerable difference between the action of a carpenter's screw and of the screw propeller: the latter, acting upon a fluid, cannot propel the vessel without causing the water to recede, while the carpenter's screw progresses thro' the wood without any such recession. The law which governs the distance which the water recedes is common to the paddle-wheel, and to all bodies moving in the water. The screw propelling is not of recent construction; we find that so early as 1727, Mr. Duquet invented an hydraulic screw machine, which he placed between two boats, connected by transverse bearing, to which the screw was affixed. Mr. Paucton, in 1768, published his 'Theory of the Screw of Archimedes;' other inventions followed, until a recent date, when Mr. George Rennie applied his comprehensive mind to the subject. Sir John Rennie and Mr. George Rennie undertook, when all other engineers declined the

order, to construct the engines for the Ship Propeller Company formed in 1836, to work out Mr. J. P. Smith's patent for the application of the screw to propel steam vessels, by placing it in a space to be left for that purpose, in that part called the 'dead-wood;' that is, the solid wood-work between the stern-post and the keel of the vessel. This screw propeller vessel was at length launched, and the engines, by the Messrs. Rennie, constructed. This vessel, named the 'Archimedes,' was considered the model vessel, and in the first instance fitted with a single-threaded screw, as shown in the accompanying diagram.

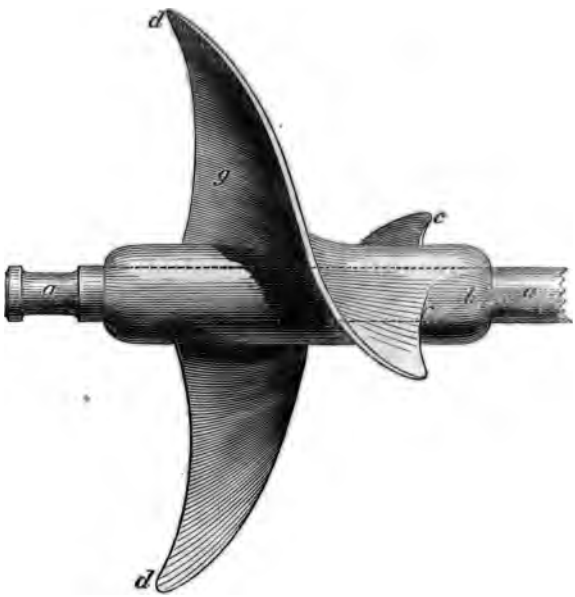


Other patents were subsequently taken out, and many experiments made. In 1838, Mr. Ericcson obtained a patent for a propeller consisting of six blades, *a a a a a a*, set at equal distances round a cylinder concentric with the axis *b*: the blades and arms were segments

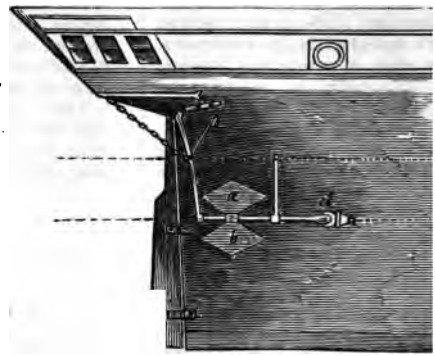


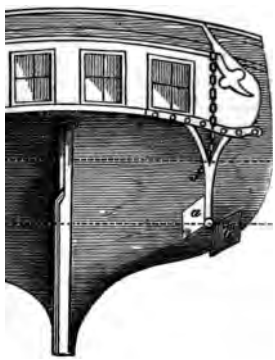


of a screw. The Archimedean screw is a helix, consisting of an inclined plane wound round a cylinder. When such a screw has communicated a retrograde motion to the water equal to its own recession, the further continuance of the thread will not only be useless, but will occasion a friction by its unnecessary surface. Mr. Rennie proposed to make the screw spiral instead of helical; the thread of his propeller would thus be generated by winding an inclined plane round a logarithmic cone or spire. The accompanying diagram will probably best explain the method adopted.



Various other methods have since been suggested and adopted; one by Mr. Blaxland. This propeller shaft rests upon a bearing in the false stern-post, which is fitted with a stuffing-box. There is an open space on the dead-wood, in which the propeller works, similar to that of the 'Archimedes,' but the propeller rests entirely upon the bearing, instead of having an after-bearing like the screw of that vessel. Captain Carpenter's invention was adopted by the Admiralty in the pinnace 'Geyser,' commanded by himself. There are in this case two propellers, which are placed in the quarters. They receive motion by means of a rotatory engine, called the disc engine. The propellers differ from all others, consisting merely of two flat trapeziums attached by arms to the axis: they are therefore not portions of a screw, though this action is helical. In May, 1843, Mr. Bennet Woodcroft was directed by the Lords of the Admiralty to





make a screw at his own cost, which they caused to be tried in the 'Rattler.' This screw was made of copper, having four blades; and it corresponded in every respect with a screw of an uniform pitch, also made of copper, in the number of its blades, its diameter, length and pitch, with this exception, that although they each commenced with the same pitch, yet Mr. Woodcroft's screw gradually increased in its pitch throughout, and terminated with an increase of 5 per cent. additional pitch. The trial of Smith's four-bladed Archimedean or true screw took place in the 'Rattler,' on the 18th of March, 1844; and on the 13th of the following month, a trial of Woodcroft's increasing-pitch screw, of four blades, was made with the same vessel. After this trial, Mr. Lloyd, the chief engineer of the Admiralty, who had been present to superintend it, stated to Mr. Woodcroft, who had also been present, that the latter screw was superior to the uniform pitch screw in two important qualities: first, that it propelled the vessel at an equal speed with less power; and, secondly, that it also propelled the vessel at an equal speed with fewer revolutions of the screw, which latter quality he considered superior to the former; but that the *difficulty* arising from having to *drive* screws so fast, constituted *the greatest* obstacle to their introduction in the Royal Navy deed, this is the admitted dif in the application of the scr a marine propeller, and the tical difference between it a paddle-wheel. The great s latter enables the speed c engines to accomplish the re velocity of the boat, where small diameter of the screw re it necessary that it should pe many more revolutions tha engine makes strokes. Hen necessity of introducing some tiplying gearing between the e and the propeller; and this tiplying gear, consisting of ca cog-wheels and pinions, i

sarily liable to frequent breakage and damage. The great object to be now achieved in the application of the screw as a marine propeller, is to introduce an intermediate gearing for multiplying the velocity, which shall not be liable to accident, or to render this gearing altogether unnecessary. Smith's screw, however, with some modifications of his former patent, now diminished to two blades, is used in the navy to some extent.

Screw-cutting Machine. The machinery adapted to this purpose varies in construction according to the notions of the different makers, but the general principle is the same in all, the difference consisting in the method of carrying it into effect. The machine is a compound of the 'slide-rest' and lathe, with a train of wheels to give motion to the former. The metal to be cut into a screw is placed between the centres of the lathe in the usual manner, and the cutting-tool is fixed upon the slide-rest, which has its lower slide made parallel to the centre line; the upper slide is only used for adjusting the cutting-tool. The screw of the lower slide has motion communicated by the train of three or more wheels; the first, or driving wheel, is fixed on the mandril of the lathe, and the last of the train is fixed on the end of the slide-screw; the other wheels are intermediate wheels. The pitch of the screw to be cut, or distance between the centres of two consecutive threads, is the space traversed by the tool during one revolution of the work, and is regulated by the sizes of the wheels, which must therefore be changed for every difference in the pitch.

The perfection to which screw-cutting has been brought, is mainly attributable to the application of the slide-rest; and the beautiful and accurate screws, of all sizes, produced by the screw-cutting machine, have contributed in no small degree to the perfection of our machinery in general, and more particularly to that of astronomical instruments.

There are also other machines, called screwing machines, for screw-cutting, which perform work of a much rougher description, such as cutting short screws on bolts, for fastening together the flanges of pipes, &c. The machine consists of a strong iron frame, which carries a mandril somewhat similar to that of a lathe, driven by a band passing over a pulley. The head of the bolt to be screwed is held by a clamp at the projecting end of the mandril, so that it revolves with it as in a lathe, the only difference being, that it is held at one end and free at the other. The dies, or two hardened steel pieces, which together form a nut, with the grooves lengthwise for cutting, are placed in a small frame, across the machine, supported by two guides projecting from the machine frame, one on each side, level and parallel with the bolt.

When the machine is set in motion, the small cross frame is brought forward, and the end of the revolving bolt is made to enter the dies, which are pressed upon it by set-screws; and as their cutting edges take effect on the bolt, the frame is carried forward on the guides till it has moved the required length; it is then brought back by reversing the motion of the machine, and the dies are tightened for another cut: this operation is repeated until the screw is of the required diameter. By fixing a tap, or cutting-screw, to the mandril, in place of the bolt, and holding a nut by the screws in the cross frame, the machine is made to cut internal screws.

Scribing, a term applied to the edge of a board when fitted upon any surface

Scribing, in joinery, the act of fitting

one piece of wood upon another, so that the fibres of both may be perpendicular to each other, and the end cut away across the fibres, so as to fit upon the side of the other

Scrin, in mining, a small vein

Scroll, a name given to a kind of ornament of general use, which resembles a band arranged in undulations or convolutions

Sculpture is the art of carving wood or hewing stone into images. It is an art of the most remote antiquity, having been practised, there is reason to suppose, before the Deluge. To this reason is assigned the expedients by which, in the first stages of society, the images of men have every where supplied the place of alphabetical characters. These, it is universally known, have been picture writing, such as that of the Mexicans, which, in the progress of refinement and knowledge, were gradually improved into the hieroglyphics of the Egyptians and other ancient nations. To make a distinction between carving and sculpture, the former belonged exclusively to wood and the latter to stone. The latter evinced vast comprehension of mental taste and study of human anatomy as well as that of other animals. In examining the various sculptures of the Egyptians, it is found that a general character prevails throughout their outlines: many valuable specimens remain to attest their greatness in this art. It is to the Greeks that great superiority is due. The art of sculpture probably was influenced by the climate over the human frame, as the violent heats of the torrid zone and the excessive cold of the polar regions are unfavourable to beauty: it is only to the mild climates of the temperate regions that it appears in its most attractive charms. The Romans displayed great talents for statuary; subsequently the Italian masters showed their eminence in the art; and in our own country the works of Westmacott and Chantrey belong to the distinguished English School. Carving in wood exists in the fine and most elaborate works of Flemish masters, and those of Gibbons and others of England are of equal talent in this pleasing art.

The Grecian marbles in the British Museum have given so much grace to British art, and to execution in the art generally, that a short description of them, and their connection with architecture, will not be unacceptable.

We learn from Athenian Stuart, that "the Temple of Minerva, called the Parthenon and Hecatompedon, was built during the administration of Pericles, who employed Callicrates and Ictinus as architects, under Phidias, to whom he committed the direction of all works of elegance and magnificence. It has been celebrated by some of the most eminent writers of antiquity, whose accounts are confirmed and illustrated in the descriptions given us by those travellers who saw it almost entire in the last century. Even in its present state, the spectator on approaching it will find himself not a little affected by so solemn an appearance of ruined grandeur. Accustomed as we were to the ancient and modern magnificence of Rome, and by what we had heard and read, impressed with an advantageous opinion of what we were come to see, we found the image our fancy had preconceived greatly inferior to the real object.

"This temple, the most costly and highly finished example of the Doric order, perhaps the largest octastyle temple of antiquity, had the advantage of the great mind of Phidias. It is to Lord Elgin's enterprise and enthusiasm for art that England owes the unique treasures deposited in the British Museum. Pausanias remarks, 'On entering the

temple called the Parthenon, all the works in what are termed the pediments (eagles) seem to relate to the birth of Minerva; those behind represent the contest of Neptune and Minerva concerning Attica; but the statue itself (of the goddess) is formed of ivory and gold.' Pausanias then proceeds to a minute description of the chryso-elephantine statue, notices other monuments of art, describes the Erechtheum, and enlarges on the colossal bronze Minerva by Phidias, called Promachus, &c. The beauty of the marble of the mountains surrounding Athens, particularly that of Pentelicus, from which the temple Parthenon was wrought, must have given a great zest to the Athenians in the cultivation of the refinement of architectural design: with more brilliancy, it is almost capable of receiving the high finish of ivory. According to Pliny, Diopœnus and Scyllis, born in Crete about the 50th Olympiad, B.C. 578, were the first sculptors distinguished in working marble, and to them are also attributed the earliest statues of ivory and gold. Of the part Phidias had in the design of the Parthenon temple, and in the production of the sculpture in particular, a diversity of opinion has existed. It has been supposed that the whole of the sculptural decorations are the 'undoubted' productions of that great artist, thus conveying to them a charm, from the association of that great name, which the unequal execution does not entitle portions of them to receive: others assert that he had nothing to do with the works, but that he may have designed the sculpture. However, the words 'skilful sculptor in marble' have been applied by Aristotle to Phidias, in opposition to 'statuary,' given by him to Polycletus, whose works were principally in bronze, in order to strengthen the probability of his having executed the marble sculpture of the Parthenon. Pliny states Phidias to have been the first who displayed and perfected the toreutic art, or sculpture formed by the combination of metals and other materials. The fertility of genius of this great sculptor, who was equally skilful in every department of his art, was surprising. He was, at the period of the erection of the Parthenon, engaged in so many and such various monuments belonging to the toreutic art, that his attention must have been occupied by them to so great a degree, that any but a general superintendence of the designs of the temple can scarcely be supposed possible. When executing the Minerva of the Parthenon, he had already completed or was engaged on, besides many other statues and groups in ivory and gold, five other statues of that goddess, probably all of them colossal, of which the Minerva Promachus, in bronze, in the acropolis, must have been upwards of 50 feet in height, having been seen from the sea. The passage of Plutarch, describing the artists of the structures of Pericles is, 'Phidias directed and superintended all the works for him (Pericles), although they had great architects and artificers; for Callicrates and Ictinus executed the Hecatompedon, or Parthenon.'"

Sculpture. Mr. Hailes, in 1825, writes the following:—"The introduction of statues of individuals, however eminent and meritorious, into squares and public places, is a novelty in this our metropolis, which, till of late years, seemed to be reserved for the sovereign and his family. We have, however, two, which, although not contrary to law, at least to any that I know of, are certainly deviations from long established custom, and a sort of invasion or trespass upon royal prerogative. That of the late Duke of Bedford, the Triptolemus of his time, in

Russell Square, is an erect figure, surrounded by the attributes of husbandry; and beneath it are some smaller figures, equally symbolic. The late Bishop of E——, going with a friend to look at this statue, was asked by him what he thought would be the fittest inscription for it. His answer was, 'Bovi. Optimo. Maximo.' It seems extraordinary that his Grace, with these emblems of agriculture about him, has not been made to look towards the country instead of the town. But he looks towards Mr. Fox, the Demosthenes of our day, in Bedford Square, sitting in a lumpish manner in a sort of curule chair, and habited in a toga, *à la Romaine*;—his neck is exposed, and the drapery, passing over one of his shoulders across his breast, might very well give occasion, as it did, to one of his old Westminster constituents, to say, 'So, Charley, you are going to be shaved, I see.' These are two very sharp remarks: one from a very highly cultivated man, and a great scholar; and the other from a very coarse observer, but equally shrewd and comical in their way. They seem to supersede the necessity of any other criterion. We are not happy in this branch of the fine arts; and the only instance in which we can pride ourselves is not of a late date, being the equestrian statue of Charles the First, by a scholar of John de Bologna, at Charing Cross. Our ill success is perhaps the less to be lamented, as works of this sort, exposed to such an atmosphere as we live in, become in a short time so much defaced as to make it very indifferent whether the workmanship be from the hand of a Glycon or a Bacon. All our monuments of this kind seem to represent our chimney-sweepers, a-foot or on horseback, rather than our kings, princes, and other great men." The late Mr. Nash observed, "that these criticisms are unjust as well as impolitic: by running down the best, we open the door to the worst artists. It is a peculiarly English feeling. If Westmacott's bronzes, which one hardly dares (in the face of criticism) to pronounce unrivalled in this country, had received their due praise, the designer of the Duke of Kent, at the top of Portland Place, would never have been suffered to libel the state of English art."

Scumbling is giving a kind of rough dotted shadow to trees, grass, gravel-walks, &c., in a drawing when it is nearly finished. It is performed with a brush having some dark brown colour in it, but nearly dry. The hairs of the brush are spread apart, then held in a slanting direction, and swept lightly over the foreground, or where the shadows are wanting. This is practised by some artists with considerable effect.

Scuppers, holes cut through a ship's side for throwing off the water from the pump. They should be disposed clear of the guns, standards, the ports below, gangways, &c.

Scutcheon, the shield represented in heraldry

Scuttles, holes cut in divers parts of the decks, exclusive of hatchways and ladderways; likewise holes cut through the ship's side for air

Scyricum Marmor, a name given by the ancients sometimes to a white, and sometimes to a yellowish marble; both used in the public buildings of the Romans, but seldom in statuary, not being capable of receiving a high polish

Seal, a device or an engraved inscription: also its impression made on wax. Kings, bishops, and prelates were accustomed to use their several devised seals. Cities, towns, corporations, companies, institutions, and public bodies, had their seals. Privy or individual seals were also of frequent use, and some very curious seals exhibit much beauty and ingenuity. That represented

in the annexed engraving is the seal of Michael Stanhope, who was Vice-Admiral of Suffolk in the time of Queen Elizabeth.

Seam, in mining, a horse-load

Seams, the opening between the planks when wrought

Secant, a true line that cuts another or divides it into two parts

Section, a vertical plan of the interior of a building, showing it as it would appear upon an upright plane cutting through it. Though rarely shown, sections are almost as indispensable as plans; like which they show the thicknesses of the walls, and, in addition, those of the ceilings and floors; and also heights, both of the rooms themselves, and of doors and windows; —moreover, the forms of the ceilings, whether flat, or coved, or vaulted. In one respect, too, a *section partakes of the nature of an elevation, the plane* parallel to the line of section being an elevation of the interior, or rather consisting of as many elevations as there are separate rooms or divisions. Sections may be described as either furnished or unfurnished: the latter show only construction and the strictly architectural parts; wherefore, if the side of a room happens to be quite plain, without door, chimney-piece, or other feature, that side or space will be a blank, or little better. Furnished sections, on the contrary, exhibit, besides what strictly belongs to the architecture and its decoration, mirrors, pictures, statues, furniture, draperies, and all other accessories. The number of sections required depends upon the nature of the plan, and what may be worth showing. If the design

worthy of it, there should be as many sections as will suffice to show every side of every principal apartment; though it may not be necessary to repeat the entire section through every floor. Sections are the *deliciæ* of architectural illustration.

Sector, in geometry, an instrument of wood or metal, with a joint and sometimes a piece to turn out and make a true square, with lines of sines, tangents, secants, equal parts, rhombs, polygons, hours, latitudes, &c.

Sedilia, a name for a seat: the term is applied to the seats for the officiating priests, inserted (and some ornamented) in the south wall of a church

Segment of a circle, a part of a circle bounded by an arc and its chord, and either greater or less than a semicircle

Segment of a sphere, any part of a sphere cut off by a plane, the section of which, with the sphere, is always a circle

Sella, (Latin,) the general term for a seat or a chair of any description. *Sella Curulis*, a chair of state.

Semaphore, in mechanics, a name given by the French to the telegraph, and latterly adopted in England to signify any machine to communicate intelligence by signs or signals

Semicircle, half a circle, or the area comprehended between a diameter and the semi-circumference

Semi-ordinate, in conic sections, a line drawn at right angles to and bisected by the axis, and reaching from one side of the section to the other

Sepia, *Seppia*, or *Æthiops-mineral*. This pigment is named after the sepia or cuttle, which is called also the ink-fish, from its affording a dark liquid which was used as an *ink* and pigment by the ancients. From this liquid our pigment sepia, which is brought principally from the Adriatic, may be obtained from the fish on our own coasts it is supposed that it ente the composition of the ink of the Chinese. Sepia powerful, dusky brown colo fine texture: it works admi water, combines cordially i pigments, and is very perm It is much used as a water- and in making drawings manner of bistre and India but it is not used in oil, in w dries very reluctantly.

Septuagint, the Greek version books of the Old Testam called because the translat supposed to have been effec seventy-two Jews, who are called the seventy interprete

Sepulchre, a grave, tomb, or pl interment. Extreme attent the sepulture of deceased characterized nations from antiquity, and to be depri it was accounted a very deg circumstance. The Roman prohibited by a law from b their dead within the city; was a field that the father Jews purchased for the sep of his wife. "Hear us, my in the choice of our sepu bury thy dead; none of us withhold from thee his sept but that thou mayest bur dead."—*Gen.* xxiii. 6. The a tombs of the East are rema for their durability, and, in instances, their beauty: the monuments on which the la ages effects no change; in instances hewn in the solid they are calculated for du equal to that of the hills in they have been excavated. garden, hewn out of a rock the sepulchre of Jesus.

As an instance of a style of m sepulture, which is rapidly e ing, may be mentioned the tery of Père la Chaise, at which comprehends above acres, thickly studded with tombs, and monuments,

with winding walks, curtained with lofty shady trees, and adorned with plants and evergreens. It contains nearly 16,000 mausolea built of the finest granite, sandstone, and polished Çarrara marble, the expense of which has been estimated at about 120,000,000 francs, or £5,000,000 sterling.

Serges, the great wax candles burnt before the altars in Roman Catholic churches

Serpentine, the *ophites*, or serpentstone of the ancients. Mona marble is an example of serpentine, and the Lizard Point, Cornwall, is a mass of it.

Serving, in navigation, encircling a rope with line or spun-yarn, to prevent its being chafed

Set-off, or *Offset*, the part of a wall, &c., which is exposed horizontally when the portion above it is reduced in thickness

Severey, a bay or compartment of a vaulted ceiling

Sewers are subterranean passages or channels for the conveyance of waste waters and other matters from towns and buildings. In order that a sewer shall act with efficiency and promote the rapid discharge of the matters committed to it, it is necessary that it be constructed thoroughly impermeable throughout its entire length, that its interior surface be even and smooth, and present no impediments to the sewage, and that its vertical declination be sufficient to prevent any suspension of the current. The sectional area of the sewer should be amply sufficient to contain the entire volume of the sewage, and its form such as will best secure its action with the minimum contents. The form of a sewer should be adapted to resist the utmost pressure to which it may be exposed externally from the surrounding materials in which it is constructed; and ready access should be afforded at intervals for examining its condition from time to time, and detecting and removing any obstruction which may possibly occur to the immediate passage of the sewage. Hence rectangular forms are utterly inapplicable for these works, the section of which should be entirely curvilinear; and theory and experience have concurred in appointing a sectional form, similar to that of the egg, as best fulfilling the conditions of strength to resist external pressure, and (the smaller curve being placed downwards) to produce the most activity in the current when the quantity of sewage is reduced to the minimum. The simplest and best rule for obtaining with circular curves a true egg-shaped or oviform section for sewers is that given in the 'Rudimentary Treatise on the Drainage and Sewage of Towns and Buildings,' belonging to the same series with this work, and which is therefore here quoted.

"Let the greater diameter, or that of the upper part of the section, equal 1; the less diameter, or that of the bed of the sewer, equal ·5; and the entire height of the section equal the sum of these, or 1·5. Then strike a semicircle of 1 diameter for the head or arch of the section, and 120° of a circle of ·5 diameter for the invert; connect the arch and invert with side arcs of 1·5 radius, the centres of these side arcs being on the produced horizontal diameter of the top arch. These arcs will be truly tangential, both to the arch and invert, and will complete a section well adapted for the practical purposes of the sewer, and, being so extremely simple in its construction, peculiarly ready of application by workmen in forming and using templates, and in testing the accuracy of the work as it proceeds. The proper size or sectional area of sewers is determinable upon the quantity of sewage, and the velocity of its passage, which latter element depends jointly upon the

rate of declivity at which the sewer is laid, and the volume of water in motion. The quantity of sewage to be conveyed from a town is made up chiefly of the bulk of the water supplied to the population, the excrementitious matters produced, and the quantity of rain-water falling upon the surface. The maximum quantity thus accruing during any given period of time will determine the minimum capacity of the sewer, calculated in combination with the rate at which the passage can be effected; while, on the other hand, the minimum quantity thus accruing will limit the proper radius of the invert of the sewer, so that the friction of the water against the surface of the sewer may be reduced in proportion to the total bulk of the sewage. All junctions of one line of sewer with another, and all changes of direction whatever, should be formed with curves of the greatest possible radius, experiment having proved that the current is impeded in proportion as the radius of curvature is reduced, and that angular junctions are still more mischievous in suspending the proper action of the channel. Thus in a sewer 2 feet 6 inches wide, a stream having a velocity of 250 feet per minute suffers a resistance from a rectangular change of direction three times that produced with a curve of 20 feet in radius, and double that produced with a curve of 5 feet radius. The inevitable effect of suspending the motion at these junctions is that the solid particles become deposited, and form a permanent bar, requiring some extraordinary action or force of water to remove it.

"It is usual to distinguish sewers according to their size and functions, as first class, or main sewers; second class, or collateral sewers; and third class, or branch sewers; while the smaller channels for conveying the contributions from individual tenements are termed *drains*. The same rules will appl to all of these as far as the objects are concerned, alth peculiar construction to be will of course depend to s tent upon the actual size channel. For the larger constructions of brick-w commonly used. These careful formation, and to rately jointed, and the in the invert at any rate s formed with a hard-drying For smaller channels or dr branch sewers, whole pipes stone-ware are coming into employment, and, if truly and carefully laid and joint form very superior ducts passage of the sewage. By of these pipes, the essenti fication of impermeability secured than with brick sev repeated joints of which ne labour and care in construct if formed with inferior mor become imperfect. As n appliances to all sewers an efficient traps or apparatus vent the escape of the noxio engendered within the char really indispensable, and t required to be simple in c tion and unerring in their The entire subject of the of towns and buildings is r receiving the attention due a necessary condition to th health; and when this in branch of engineering scier have been thoroughly inve by qualified public officers, hope for the most useful a tary practice, based upon principles, and for corres amendment in all that per the subterranean ways of ou towns, and dwellings."

Palladio says, "The gre mon sewer or the general or sink of all the filth o was near the Senatorian called S. Marca,—a perfor Tarquinius Superbus. h

strange things of its largeness, viz. that a full laden hay-cart could drive through it: upon measuring, I have found it to be 16 feet diameter. Into this all other sewers of the city do empty themselves, which is the reason that sturgeons taken between the Senatorian and Sublician bridges are better than others, feeding on the filth coming out of this great sewer."

Sextant, in geometry, the sixth part of a circle; in navigation, &c., an astronomical instrument made like a quadrant, but containing only sixty degrees

Shaft, in architecture, the body of a column or pillar; the part between the capital and base. In mediæval architecture the term is applied to small columns clustered round pillars, or used in the jambs of doors and windows.

Shaft, in mill-work, a large axle, in contradistinction to a small one, which is called a spindle: thus we say, 'the shaft of a fly-wheel,' 'the spindle of a pinion.' Shafts are said to be lying when they are in a horizontal direction, and vertical when they are upright.

Shaft, in mining, a sinking or pit, either in the lode or through the country

Shafted impost: according to Professor Willis, "those imposts which have horizontal mouldings, the sections of the arch above and of the shaft or pier below such horizontal mouldings being different." The latter point is the distinction between what he terms shafted and banded imposts: "in banded imposts, the sections above and below the impost-moulding are alike, the shaft or pier seeming to pass through its capital."

Shaken, plank or timber which is full of clefts, and will not bear caulking or fastening; generally called *shakey*

Shambles, stalls on which butchers expose their meat for sale. The shambles, or market-place for the sale of flesh, at Frankfort on the Maine, is a curious and ancient example of early shambles

Shank, the space between the channels of a triglyph

Shank-painter, a chain bolted to the top-side abaft the cat-head, to lower the anchor of a ship

Sheave, in mechanics, a solid cylindrical wheel, fixed in a channel within a *block*, and moveable about an axis; being used, in connection with suitable tackle, to raise heavy weights, or to increase the mechanical powers applied to remove any load

Sheers, in mining, two very high pieces of wood, placed in nearly a vertical position in each side of a shaft, and united at the top, over which, by means of a pulley, passes the capstan rope: this is for the convenience of lifting out, or lowering into the shaft, timber or other things of great length and weight

Sheers, in ship-building, &c., are masts or large spars set across each other at the upper ends, by which contrivance very heavy bodies, such as frame-timbers, masts, &c., are raised

Sheer-hulk, in the navy, an old seventy-four cut down to the lower deck, and fitted up with a pair of sheers, for the purpose of taking out the lower masts of ships preparing for sea

Sheer-strake, the strake under the gunwale in the top-side; it is generally worked thicker than the rest of the top-sides, and scarfed between the drifts

Sheet, in navigation, a rope fastened to one or both corners of a sail, to extend and retain it in a particular situation

Sheet Anchor, in navigation, the largest anchor of a ship

Sheriff's Posts, two ornamental posts or pillars, set up one on each side of the house of a sheriff or chief magistrate

Shift, the time a miner works in one day

Shift, of timber or plank, is over launching without either piece being reduced, as the timbers of the frame, or plank in the bottom

Shingle, coarse sand and pebbles deposited by the surge, accumulating in banks and forming dangerous shoals. Lieut.-Colonel Reid, in the second volume of the 'Professional Papers' of the Corps of Royal Engineers, makes the following observations on the moving of the shingle of the beach along the south coast of England:

"The prevailing winds being westerly, and the highest seas rolling from the south-west, the pebbles of the beach are gradually carried to the eastward, and a constant supply is furnished by the falling away of the cliffs. On this coast, therefore, groins so constructed as to prevent the moving shingle from pressing to the eastward cause an accumulation of pebbles.

"It has been ascertained, from observation, that the pebbles of the Devonshire coast are forced to the eastward, along the coast of Dorsetshire, as far as the Chesil Bank. The stone pier of Lyme Regis, called the Cobb, does not, as might have been expected, arrest their progress; for, in south-west storms, they are driven over the pier, and the crews in the harbour have had to quit the decks of their vessels, on account of the stones driven over the pier falling on the men. On this account, within a few years, a high wall has been constructed to stop the progress of the shingle at this point. The natural consequence to be expected from this wall is, that the shingle will accumulate on the west side of Lyme Regis pier, until it shall roll round the pier-head, as at the harbour of Dover.

"The Chesil Bank is not composed of calcareous pebbles, (as stated in a work of deservedly very reputation,) but mostly consists of silicious stones, worn to a very remarkable degree of uniformity of shape and also of size (when taken from the same point) by long attrition upon the coast. The largest pebbles have been carried furthest to the east; and the regularity with which they are arranged, according to their size, is very remarkable.

"The progress of the shingle is here first arrested by the Isle of Portland, owing to the projection of that point of land in a line somewhat to the westward of south, and the shingle bank stops just where the land trends in a south-west direction.

"The Chesil Bank, at that part of it nearest the Isle of Portland, is from 20 to 30 feet above the ordinary high-water mark. On the west side it is steep, and the water deep close to the shore; but on the east side it has a gentle slope, with a base of 200 yards, to the above height of 20 or 30 feet.

"This gentle slope on the east side is owing to the accumulation of water on the opposite side during westerly gales, which finds a passage through the gravel bank, washing it into little ravines, and carrying down stones by its current. In very severe storms the sea washes over this bank; and it did so on the 23rd of November, 1824.

"A dangerous shoal of coarse sand, called the Shambles, which lies off the south-east point of the Isle of Portland, is in all probability formed by the tides; but the Chesil Bank is formed by the waves breaking on the shore in south-west gales; and it is important that these two causes, and their resulting consequences, should always be separately considered.

"Silicious or very hard pebbles only withstand long rolling on the beach, whilst calcareous stones soon become ground into sand. As the silicious pebbles do not pass round Portland Island, sand only

is found on the shore of Portland Roads; and it is calcareous, effervescing strongly with muriatic acid.

"Scarcely any gravel is to be seen between Portland Roads and Weymouth. Within the *Abergavenny*, an East India ship, which sunk thirty years ago in the mouth of Weymouth Bay, there is no gravel, and but little sand. East of Weymouth it again begins to collect; but each little headland, acting as a groin, retains much of it in the small bays. Round St. Alban's Head its action has not been observed, but at Christchurch the quantity is considerable, and at Hurst Castle it is very large.

"The Isle of Wight, and the strong current running through the Needles, here again a second time stop its eastward movement; and it forms, nearly in the mid-channel, a shoal called the Shingles, the easternmost end of which (by the action of the westerly winds on one side, and the current of the Needles on the opposite,) becomes heaped up above high-water mark into an island, varying in shape and size with every storm, and sometimes disappearing altogether.

"The pebbles coming from the westward must be driven across the north channel to this bank; but they do not pass across the south and principal channel of the Needles to the Isle of Wight, as is evident from local inspection; for those of the Isle of Wight are of a different colour, being black flints from the chalk, whereas those on the side of Hurst Castle are generally yellow.

"The effect of the prevailing wind, in driving the gravel along the coast from west to east, is not less evident on the south of the Isle of Wight than elsewhere. It passes eastward until it reaches Sandown Bay, where the artificial groins, kept up at considerable cost, arrest a certain portion; but the surplus is poured over these groins, and, falling on the east side, continues its course.

"The gravel which passes Portsmouth does not appear to come from the westward of Hurst Castle, for the shores just within the Needles are mud without stones. A new system commences within the Solent. A large quantity of shingle is furnished from the gravelly soil of the south coast of Hampshire; and this shingle is likewise driven eastward, sometimes returning westward when easterly winds prevail, but the balance of its progress is always towards the east.

"Hurst Castle, Calshot Castle, and Blockhouse Fort, Portsmouth, all stand on similar tongues of shingle, formed on the west sides of their respective passages by the prevailing westerly winds.

"At Hurst Castle the gradual additions to the end of the strip of shingle may be plainly seen; for Nature there records her own history in a very visible manner. An ordnance landing-place 30 feet long, which was constructed in 1806, and stood in the sea, became entirely buried in gravel; and many succeeding lines of high-water mark may be distinctly traced to the eastward of Hurst Castle.

"Similar traces of many former lines of high-water mark are also to be seen near Southsea Castle; and immediately on the west of Fort Monkton, six distinct lines of high water may be counted; and some of these probably belong to very remote periods of time.

"The direction of the line of coast, with reference to the prevailing gales, seems to determine where the shingle will accumulate, or where the sea will be most likely to encroach upon the land; and seems to be one of the most important points to study as regards the subject of opening bar-harbours.

"The south-easterly direction of the beach at Southsea would appear to be one of the causes why the entrance of Portsmouth Harbour is kept as clear as it is, by the current

running out of it; for this direction of the land prevents the water from spreading itself on both sides, at the ebbing tide, as it does at the entrance of Langston Harbour, over banks of gravel; and this direction at Southsea appears just sufficient to allow the shingle to be set to the eastward by the prevailing gales.

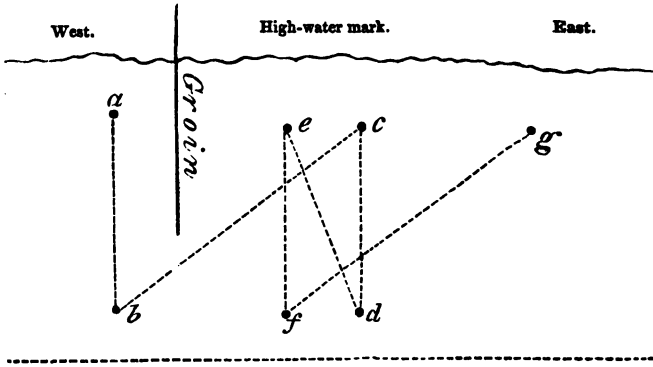
"It well deserves consideration, whether embankments (on the south coast of England) run out on the eastward of bar-harbours, in a line parallel to the line formed by nature on the east side of Portsmouth Harbour, would not lead to a similar effect as that produced there in keeping open one principal channel. By a proper system of groins on the west side of such harbours, shingle coming from the westward would be stopped, and much of the materials which now form the bars might be arrested in their course.

"The slope of the beach is flatter after a southerly gale, and its average slope is about 1 foot in 9.

"If groins are not carried far enough in-land, the sea in south-west storms (on the south coast) will break round and insulate them. If they are not high enough at high-water mark, the gravel will be carried over them to the eastward; and if they are too short, it will pass round the outer end of them.

"During southerly gales, it is frequently said, that the gravel is 'carried into the sea,' because the receding waves draw it down; but it is again driven back, and if the wind be south-west it is set to the eastward.

"The annexed figure, in which a pebble (*a*) passes to (*g*), following a course indicated by the alphabetical order of the letters, will explain what is here meant, and show the way in which the gravel passes by groins which are too short.

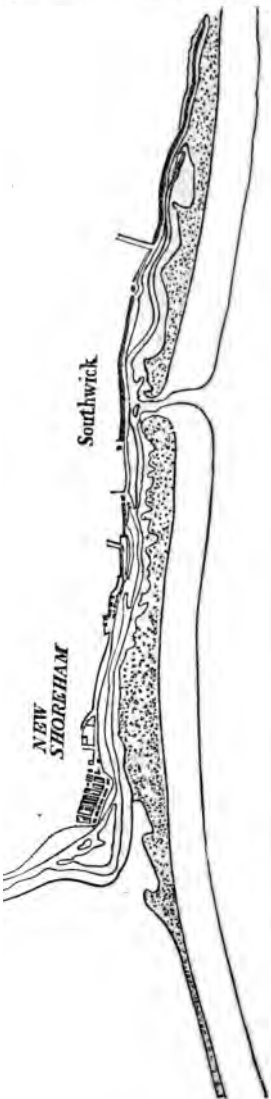


Foot of the slope of gravel.

"From this figure it will also be understood, why a single plank removed from a wooden groin will cause the beach at such place of removal to be carried on forward; and hence the importance of constructing groins of materials not liable to such accidents.

"The point of shingle on which Calshot Castle now stands was once an island, and called, in 1717, Crown Island; since which time the opening has filled in with gravel. The point on the west side of Christchurch Harbour is now lengthening annually; and the mouth of that harbour and its bar become every year more and more removed

the eastward, and if left to nature ay continue to be removed east-



ward until the water from that estuary shall re-open a fresh passage for itself in a more direct line, as the water seems to have done at the harbour of Shoreham.

"At such harbours as Portsmouth it would be desirable, by means of the apparatus for enabling persons to descend and examine the bed of the sea, to observe and determine the precise mode of the action of the shingle at the entrance of harbours.

"The sand being blown by the wind, as well as driven by the surge, it frequently covers the coarser shingle, where it is retained by the *carex arenaria*, a grass which roots at every joint."

(Much valuable information on the subject of encroachments of the sea upon the land will be found in Lyell's 'Geology.')

Shingles, in house-building, small pieces of wood sawed to a certain scantling, used in roofing, instead of tiles or slates

Shittim wood, a valuable kind of timber, of which Moses made the greater part of the tables, altars, and planks, belonging to the tabernacle: it grows in the deserts of Arabia, and is like white-thorn in its colour and leaves, but not in size, as the tree is so large that it affords very long planks: the wood is hard, tough, smooth, without knots, and extremely beautiful; so that the rich and curious make screws of it for their presses

Shivers, in navigation, the little round wheels, of wood or metal, in which the rope of a pulley or block runs

Sholes, pieces of plank put under the shores where there are no groundways

Shores, pieces of timber fixed to support a ship

Shrines, tombs, or decorated monuments of ornamental tabernacle-work, as they are applied to the entombment of royal and noble persons: several very fine examples exist in the cathedrals and abbey

churches: the term is also applied to a cabinet in which sacred things are deposited

Shunt, a term applicable to the management of railway trains, to remove a carriage or train off the main line. When an engine, carriage, or train is moved off the main line to a siding, it is then said to be 'shunted.' It is most probably derived from the word 'shun:' in the old English Romance 'Mort Arthure' we find the word 'schunte' used in this sense, to put off; and in other early works the word 'shunted' may be found, with the meaning, to move from.

Side chains, chains and hooks fixed to the sides of the tender and engine for safety, should the central drag-bar give way

Sidereal year, that space of time which astronomers compute the sun is moving from any fixed star till it returns to it again, reckoned at 365 days, 6 hours, and almost 10 minutes

Signal lamps, railway lamps with a bull's-eye glass in front. Each lamp has a recess between the burner and bull's-eye, for dropping in any particular coloured glass, according to the light which is to be shown. The lamp has also recesses for holding these glasses, so that the engine-man can at once pick out a red, green, or blue glass, and put it in front as he may require it.

Sill, the lower horizontal frame of a door or window; a threshold

Silt, in hydrography, &c., mud deposited by rivers, tides, &c., generally in still parts or eddies, and also in lakes or hollows filled with still water

Silver is sometimes found in the metallic state, and as chloride and sulphide, besides alloyed with gold, copper, and other metals. It is a pure white brilliant metal, of great ductility, capable of being drawn out into very fine wires. It melts at 1873°, and absorbs a large quantity of oxygen, which, disengaging on cooling, gives it a white, frosty appearance: when impure, it does not do so. It is a metal used in great abundance as a coin in all countries, also for plate, for vases, candelabra, cups, &c.

Sinking, in mining, digging downwards; in rising and sinking a shaft, one set of men sink from a certain level, while another set rises from a lower level to meet them

Siparium, in the time of the Romans, a piece of tapestry stretched on a frame, which rose before the stage of the theatre

Siphon, or *Syphon*, in hydraulics, a crooked pipe through which liquors are conveyed

Sissoo is one of the most valuable timber-trees of India, and with the *saul* is more extensively used than any other in north-west India. The ship-builders in Bengal select it for crooked timbers and knees; it is remarkably strong; its colour is a light grayish brown with dark-coloured veins.

Spindle-tree, a shrubby tree, with a yellow wood similar to the English box-wood: it is turned into bobbins and common articles

Site, the situation of a building; the plot of ground on which it stands

Site, in landscape, signifies the view, prospect, or opening of a country, derived from the Italian word *sito*, situation; and it is in use among painters, as being more expressive

Sketch, a slightly made picture, in which the general effect is attended to, but not always the details, and from which more finished works are painted: so also with sketches in architecture, giving the correct outline of a building without filling up with the detail.

Skew, or *Askew*, as applied to masons' work, an oblique arch

Skirting, a narrow board forming a plinth to an internal wall

Skreens were either of needle-work or painted: in the time of Henry

VIII. is noticed a skreen as a new year's gift from Luke Hornebound, a painter, to that monarch

Skylights, glass frames placed in a roof with one or more inclined planes of glass

Slaking of Lime. Quick-lime, taken as it leaves the kiln, and thrown into a proper quantity of water, splits with noise, puffs up, produces a large disengagement of slightly caustic vapour, and falls into a thick paste. So much heat is produced in slaking, that part of the water flies off in vapour. If the quantity of the lime slaked be great, the heat produced is sufficient to set fire to combustibles: in this manner vessels loaded with lime have sometimes been burnt. When great quantities of lime are slaked in a dark place, not only heat, but light also, is emitted. The specific gravity of pure lime is 3·08.

Slate, an argillaceous stone, readily split, and employed to cover buildings, and also for other purposes: it is quarried in large pieces

Slating is employed by builders for covering in the roofs of buildings. The slates principally in use in London are brought from North Wales.

Sleepers, pieces of timber employed to support others, and laid asleep, or with a bearing along their own length: sleepers denote more particularly those timbers which are placed lengthwise on walls to support the joists of a floor; they are employed on railroads as longitudinal bearings for the rails to rest upon

Sleepers, or *Transome-knees*, are fixed withinside a ship abaft, one arm laying on the foot waleing, and the other extended up the transoms

Slickings, narrow veins of ore

Slide, a vein of clay, which, intersecting a lode, causes a dislocation vertically

Slide-rest. This apparatus, the invention of Mr. Henry Maudslay, is of the utmost importance for perfecting and accelerating the construction of machinery. Before its invention, cylindrical turning was a work of manual labour, and was attended with so much difficulty and expense, when the cylinders were either large in diameter or of moderate length, that it was necessary to avoid using them in many cases; and plane surfaces being even still more expensive, in consequence of the very imperfect and laborious operations of chipping and filing them, many very valuable inventions could not be carried into effect on account of the inaccuracy and expense attending their construction. The invention of the slide-rest, forming an all-important part of that of the planing machine, has entirely removed both of these difficulties, and cylindrical turning and planing are now the cheapest and most perfect of mechanical operations.

The office of the slide-rest, as applied to lathes and turning machines, is to *hold, engage, and direct* the turning-tool, and it may be kept in motion either by hand or by self-acting machinery.

When applied to a small lathe, it is generally moved by hand; but in large machines for heavy work, where the time of action is considerable, it is moved by machinery attached to the lathe. The work to be turned being placed in the usual way between the two centre pieces of the lathe, the lower part of the slide-rest is fixed under it on what is called the bed of the lathe: the use of this part of the slide is to move the tool to or from the work, which it effects by means of a slide, at right angles to the work, moved by a screw and handle: this slide has fixed upon it, by a swivel joint, the upper part of the apparatus.

The upper part has also a slide moved by a screw and handle, and generally placed at right angles to the lower slide: the principal use

of this upper slide is to move the cutting-tool which is fixed upon it parallel to the centre line of the lathe; but it can be so placed, by aid of the swivel-joint, as to cause the tool to advance at any required angle with the centre line of the lathe. Thus two direct movements are obtained: the first to set the tool to the work, and the second to move it either to the right or left, in a line parallel with the work, or at any given angle with the first.

The slide-rest principle enters largely into the construction of all kinds of machinery, from the most minute to machines of vast magnitude, where by its aid ponderous masses — such for instance as railway turn-tables 36 feet in diameter — are operated upon with a precision unattainable by any other means.

Slide-valve, in locomotive engines, the valve placed in the steam-chest to work over the steam-ports. It regulates the admission of steam to the cylinder from the boiler, and the escape of the steam from the cylinder to the atmosphere. Its form is that of an arch in the centre, with a flat face all round to keep it steam-tight on the face of the steam-ports. It is by the arched part that the steam escapes to the atmosphere. It is a very simple valve, and answers its purpose well, with one draw-back, namely, the pressure of the steam upon it being unbalanced by any counter-pressure. Numerous attempts have been made to relieve this pressure, some of which it is hoped will be successful. In stationary engines the contrivances differ materially, as shown below.

Fig. 1.

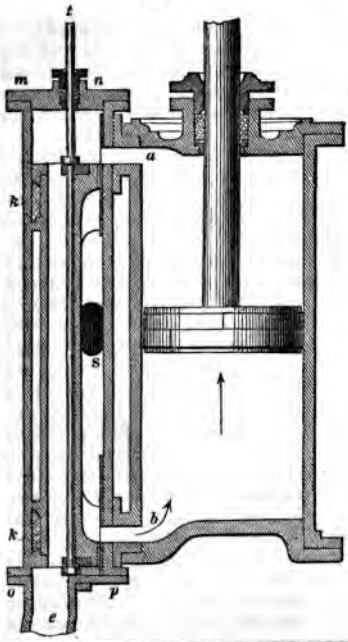


Fig. 2.

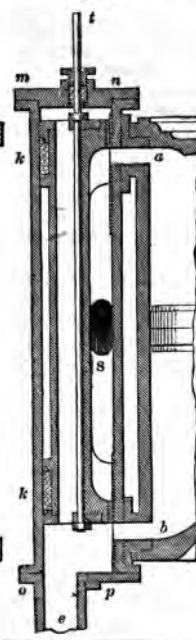


Fig. 3.

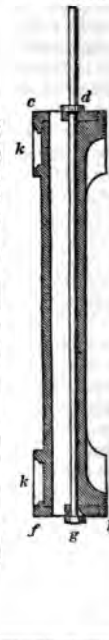


Fig. 1 represents in section the cylinder, piston, and slide: S is the mouth of the steam-pipe coming from the boiler; *e* is the pipe leading to the condenser; *t* is the rod which is attached to the slide, moving through a stuffing-box, *m n*. This slide is represented in longitudinal section, separately, in fig. 3, and in transverse section in fig. 4. In the position of the slide represented in fig. 1, the steam passing from the boiler enters at S, and passes to the bottom of the cylinder through the opening *b*, where it acts below the piston, causing it to ascend. The steam which was above the piston escapes through the opening at *a*, and descending through a longitudinal opening in the slide behind the mouth of the steam-pipe, finds its way to the pipe *e*, and through that to the condenser.

When the piston has reached the top of the cylinder, the slide will have been moved to the position represented in fig. 2. The steam now entering at S passes through the opening *a* into the cylinder above the piston, while the steam which was below it escapes through the opening *b* and the pipe *e* to the condenser.

Fig. 4.

The form of the valve, from which it derives its name of D-valve, is represented in fig. 4. The longitudinal opening through which the steam descends then appears in section of a semicircular form. The packing at the back of the slide is represented at *k*; this is pressed against the surface of the valve-box.

Slide-valve lap, Outside, in locomotive engines, that portion of valve which would overlap the steam-ports when placed over them. If the steam-ports measure 8 inches over all the ports, and the valve be 10 inches broad, this would be an overlap of 1 inch on each side of the ports, and is called the 'lap' of the valve. Expansion was formerly regulated by the extent of lap only, but it is now regulated by both the lap and the expansion gear, which gives greater scope in doing so. *Inside lap* is the portion of the valve face which would overlap the inside of the steam-ports when placed over them; for if the steam-ports were 4 inches from inside of the one port to the inside of the other port, and if the arched part of the valve only measured $3\frac{7}{8}$ inches across, this would give $\frac{1}{16}$ of an inch lap on each side, which is called *inside lap*.

Slide-valve lead, in locomotives, the width which the steam-port is opened by the slide-valve when the piston is at the end of the stroke. It varies from $\frac{1}{8}$ to $\frac{1}{4}$ an inch, according to the work required. The lead is obtained by fixing the eccentric on the axle, a little in front of the crank, by which arrangement the steam-port is opened in front of the direction in which the piston is moving before the latter has completed its stroke. By these means the steam-port is thrown quickly open when the piston commences its return stroke, and has at once the full pressure of the steam against it.

Slide-valve travel, the distance which the slide-valve travels in one direction for each stroke of the piston. This is from 4 to $5\frac{1}{4}$ inches generally, but is reduced by each variation of the expansion gear, and its travel is taken for both the front and back strokes of the piston for each notch where the handle is fixed. The up and down quarter-revolutions of the crank do not equally draw the piston the half length of the cylinder, and this and the expansion gear so far affect the working of the slide that it is necessary to take the front and back stroke working separately.

Setting the slide-valve: the eccen-

tric is brought as much before the crank as to give the required lead to the slide-valve when the crank is on the centre, that is, in a straight line with a cylinder. The handle is then moved to each separate notch, and the position of the slide and piston carefully taken for each variation. These are then recorded in the following manner:

Slide-valve and Piston Motions' Register.—Working of expansion gear.

Engine, 185

	Inches.		Inches.
Diameter of cylinders . .	18	Outside lap of valve . . .	1
Length of stroke	24	Inside lap of valve . . .	$\frac{1}{32}$
Size of steam-port . . .	15 × 2	Size of exhaust-port . .	15 × $3\frac{1}{2}$

No. of notch in reversing handle guide.	Travel of slide-valve.	Lead of slide-valve.	Steam cut off.		Exhaust opens.		Compression begins.		Steam-port opens.		Diameter of blast-pipe.	REMARKS.
			Front stroke of piston.	Back stroke of piston.	Front stroke of piston.	Back stroke of piston.	Front stroke of piston.	Back stroke of piston.	Front stroke of piston.	Back stroke of piston.		
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	Balance piston for slide-valves.
1	$5\frac{1}{8}$	$\frac{11}{32}$	$19\frac{7}{8}$	19	$22\frac{3}{4}$	$22\frac{3}{8}$	$22\frac{1}{2}$	$22\frac{3}{16}$	$1\frac{1}{2}$	$1\frac{3}{4}$	$5\frac{1}{8}$	
2	$4\frac{1}{2}$	$\frac{11}{32}$	$18\frac{9}{16}$	18	$22\frac{3}{16}$	$21\frac{7}{8}$	22	$21\frac{5}{8}$	$1\frac{3}{16}$	$1\frac{3}{8}$	,,	
3	4	$\frac{11}{32}$	$16\frac{5}{8}$	$16\frac{5}{16}$	$21\frac{3}{8}$	$21\frac{1}{8}$	$21\frac{1}{4}$	21	$\frac{15}{16}$	$1\frac{1}{16}$	,,	
4	$3\frac{1}{2}$	$\frac{11}{32}$	$13\frac{5}{8}$	$13\frac{3}{8}$	$20\frac{5}{16}$	$19\frac{13}{16}$	20	$19\frac{1}{8}$	$\frac{11}{16}$	$\frac{15}{16}$	,,	
5	$3\frac{1}{8}$	$\frac{11}{32}$	$9\frac{1}{2}$	10	$18\frac{7}{16}$	$18\frac{1}{16}$	18	$17\frac{9}{16}$	$\frac{9}{16}$	$\frac{9}{16}$	,,	Centre notch.
6	$2\frac{11}{16}$	$\frac{11}{32}$	$5\frac{7}{16}$	6	$15\frac{5}{8}$	15	$15\frac{1}{4}$	$15\frac{1}{4}$	$\frac{11}{32}$	$\frac{11}{32}$	,,	

The above measurements are carefully taken and registered by the mechanic who sets the slide-valves.

Slide-valve rod guide, in locomotive engines, a bracket fixed to the boiler, the lower end of which is fitted for the slide-valve rod to work through. A set-screw is useful in this guide for fixing the rod when the valve has to be disconnected.

Slide-valve rod and frame, in locomotive engines: the frame is fitted on to the top part of the valve, and the rod connects the frame with the slide-block, or rocking-shaft, according to the description of valve-gear of the particular engine

Slide-valve motion, in locomotive engines, a short motion similar to the piston-rod motion, connecting the quadrant to the slide-valve by parallel guides

Sliding rule, a rule constructed with

logarithmic lines, formed upon a slip of wood, brass, or ivory, inserted in a groove, in a rule made to slide longitudinally therein, so that by means of another scale upon the rule itself the contents of a surface or solid may be known

Slimes, mud containing metallic ores, mud or earthy particles mixed with the ores

Slit deal, a name for inch and a quarter-inch deal cut into two boards

Sloop, in navigation, a small one-masted vessel, the mainsail of which is attached to a gaff above, and to a long boom below. The word is also applied to any small ship.

Sluice, in hydraulics, a water-gate, a flood-gate, a vent for water

Smelting is the process of separating metals from the earthy and other matters with which they are combined in the state of ore. Of this operation, as conducted upon the ores of iron, copper, lead, and tin, the following is a brief description:

Smelting Iron. The reduction of iron ore is effected in a furnace in which, the required intensity of heat being obtained by a current of air driven rapidly into the furnace, has received the name of a blast-furnace. The kind of furnaces employed, the quantity of ore or mine, as it is termed, reduced at each heat, and the peculiar method of conducting the operation, vary widely in different countries and counties, and have some reference in detail to the precise quality and composition of the ore to be treated. Previous to the year 1740, the smelting of ores of iron was, in England, performed solely with the charcoal of wood, the ores operated upon being principally the brown and red hematites, or rich ores, that is, containing a large proportion of metal with a small quantity of earthy materials. In the treatment of this class of ores, it may be observed that very little improvement has yet been effected, the modern processes having been chiefly applied to the leaver ores, such as blackband, &c. The expensiveness and comparative scarcity of charcoal as a fuel for the smelting of iron ores, induced those engaged in the art to attempt the substitution of coal for wood-charcoal; and by the year 1788, these attempts had so far succeeded, that there remained only 24 out of 59 charcoal furnaces, while 53 furnaces had been established in which coal, burned into the form of coke, was used for the smelting of the ore. Since that date, the extension of this process has proceeded rapidly, and the total quantity of metal produced has experienced a corresponding augmentation. At the present time, the Backbarrow Iron Company are nearly the only smelters of iron with wood-charcoal in the kingdom. The two principal seats of the iron manufacture in Great Britain are in Staffordshire and South Wales. In the former district, comprising the neighbourhoods of Dudley, Bilston, Wednesbury, &c., the smelting or blast furnaces are constructed almost wholly of bricks. They are usually of a conical form externally, and sometimes pyramidal, the plan being a square or rectangle. In the interior they are mostly circular in form, except in that part called the hearth. The fuel and the ore to be smelted are fed into the furnace from the top, and its height being from 40 to 50 feet, an ascending platform or inclined plane is constructed for wheeling up the barrows in which the materials are conveyed. The pipes through which the air is driven into the furnace (by a steam engine) are called the tuyères, and are usually two, but sometimes three in number. The relative quantities of coal, ironstone, and limestone, which are put into the smelting furnaces of Staffordshire for the production of each ton weight of iron produced, are about 50 cwt. of coal, 50 cwt.

of mine, previously calcined, and from 12 to 16 cwt. of limestone, the latter material being added as a flux to promote the fusion of the mass. The Conegree furnace, near Dudley, may be instanced as a good example of a blast-furnace adapted for the economical smelting of iron ores. It is 54 feet in height, 5 feet in diameter on the hearth, and 12 feet above, widening upward to a diameter of 13 feet 9 inches, and reduced to 8 feet above the platform, on which the charges are delivered. The quantities of materials employed in this furnace to make one ton of pig-iron, are of coal 2 tons and 5 cwt., or of coke 37 cwt., charred mine 2 tons 5 to 10 cwt., limestone 13 to 16 cwt.

Each charge delivered into the furnace consists of 9½ cwt. of coke, 12 cwt. of charred mine, and 4 cwt. of limestone. At this furnace 115 tons of pig-iron have been made in one week. The cylinder from which the air is blown through the tuyères into the furnace is 72¼ inches in diameter, and the stroke is 7 feet in length. Originally there were five tuyères for the introduction of the blast, one muzzle being 2¼, two others 2⅛, and the other two 2 inches in diameter. Subsequently these were changed to four muzzles, of the respective diameters of 3¼, 2¼, 2⅛, and 2 inches.

Smelting Copper. Copper ore, as smelted in South Wales and other places, usually consists of pyrites (composed of sulphuret of copper and sulphuret of iron in nearly equal proportions), and vein-stone. The earthy matters combined with the pyrites are commonly silicious, and the process of smelting consists in alternate roastings and fusions. The first of these operations is, calcining the ore in furnaces in which the heat is applied, and increased gradually, till the temperature be as high as the ore can support without melting or agglutinating, when the ore is thrown int arch formed under the sole furnace. The second operati fusion of the calcined ore, is formed in a luted furnace, th having been spread uniformly the hearth, and fluxes, such as sand, or fluor-spar, being when required, although th cessity for this addition is to be obviated by a careful a ture of ores of different qua the several earthy compone which shall serve as fluxes i fusion of the mass. These processes of calcination and are repeated alternately unt ore is completely freed from earthy materials, and pure m obtained.

Smelting Lead. The ores after being sorted, cleansed, g and washed, are roasted in fur which are without any bl blowing apparatus, the ores separable from the metal great fusibility. Several furnaces are usually connecte one chimney-stalk, to wh series of flues about 18 inches conduct. The melted lead freely from the ore and is off into the moulds in succ quantities, the ore being repe turned over, and a small qu of coal added over the b mass at each drawing.

Smelting Tin. This proces sists of the calcining or roast the ores after they have been cl sorted, stamped, and washed. calcining is performed in a beratory furnace from 12 to 1 long and 7 to 9 feet wide. hearth of these furnaces is zontal, and they have only opening, which is in the fron closed by an iron door. Th phureous and arsenical va which arise from the ore are ducted by chimneys over the of the range of furnaces into zontal flues, in which the condensed. In the process

cination, which occupies from 12 to 18 hours, according to the quantity of pyrites contained in the ore, 6 cwt. of ore are treated at once, and the materials are stirred from time to time, to prevent them from agglutinating.

Smoke, Prevention of. There is perhaps no subject so difficult, and none so full of perplexities, as that of the management of a furnace and the prevention of smoke. Mr. Fairbairn, in his Report to the British Association on the Consumption of Fuel and Prevention of Smoke, observes, — "I have approached this inquiry with considerable diffidence, and after repeated attempts at definite conclusions, have more than once been forced to abandon the investigation as inconclusive and unsatisfactory. These views do not arise from any defect in our acquaintance with the laws which govern perfect combustion, the economy of fuel, and the consumption of smoke. They chiefly arise from the constant change of temperature, the variable nature of the volatile products, the want of system, and the irregularity which attends the management of the furnace. Habits of economy and attention to a few simple and effective rules are either entirely neglected or not enforced. It must appear obvious to every observer, that much has yet to be done, and much may be accomplished, provided the necessary precautions are taken, first to establish, and next to carry out, a comprehensive and well-organized system of operations. If this were accomplished, and the management of the furnace consigned to men of intelligence properly trained to their respective duties, all these difficulties would vanish, and the public might not only look forward with confidence to a clear atmosphere in the manufacturing towns, *but the proprietors of steam engines would be more than compensated* by the saving of fuel, which an improved system of management and a sounder principle of operation would insure. The attainment of these objects — the prevention of smoke, and the perfect combustion of fuel,—are completely within the reach of all those who choose to adopt measures calculated for the suppression of the one and the improvement of the other.

"On presenting to the British Association an inquiry into the merits of Mr. C. W. Williams's Argand Furnace compared with those of the usual construction, it was found, from an average of a series of experiments, that the saving of fuel (inclusive of the absence of smoke) was in the ratio of 292 to 300, or as 1 : 1·039, being at the rate of 4 per cent. in favour of Mr. Williams's plan. Since then a considerable number of experiments have been made by Mr. Houldsworth, Mr. Williams, and others, which present some curious and interesting phenomena in the further development of this subject."

In order to determine, by a series of comparative results, the law on which perfect combustion is founded, and its practical application insured, Mr. Fairbairn made the following points the subjects of inquiry:

I. The analysis or constituents of coal and other fuels.
II. The relative proportions of the furnace, and forms of boilers.
III. The temperature of the furnace and surrounding flues.
IV. The economy of fuel, concentration of heat, and prevention of smoke.

Smoke-box, the end of the boiler on which the chimney is placed. Locomotives with inside cylinders have them placed in this box, which keeps both them and the steam-pipes at a high temperature.

Smoke-box door, the door in front of the smoke-box, by which access is gained to the cylinders or steam-pipes, and other parts placed in this box

Snake wood, a kind of speckled wood used in Demerara, Surinam, &c., for the bows of the Indians: the colour of the wood is red hazle, with numerous black spots and marks, which have been tortured into the resemblance of letters, or the scales of reptiles. When fine, it is very beautiful, and is scarce in England: chiefly used for walking-sticks, which are expensive. The pieces that are from 2 to 6 inches in diameter are said to be the produce of large trees.

Snow, in navigation, the largest of European two-masted vessels. The sails and rigging are exactly similar to those of a ship, only behind the mainmast of a snow there is a small spar or mast, fixed into a block of wood on the quarter-deck, which carries a sail resembling the mizen of a ship.

Snying, in navigation, a circular plank edgewise, to work in the bow

Socle, in architecture, a flat square member under the bases of the pedestal of statues and vases

Soffit, in architecture, any timber ceiling formed of cross-beams or flying cornices, the square compartments or panels of which are enriched with sculpture, painting, or gilding

Sol, in heraldry, denotes *or*, the golden colour in the arms of sovereign princes

Solar month, that space of time occupied by the sun in going through one sign or a twelfth part of the zodiac

Solar System, in astronomy, the order or supposed disposition of the celestial bodies which move round the sun as the centre of their motion

Solar year, that space of time in which the sun returns again to the ninoctial or solstitial point, which is about 365 days, 5 ho and 50 minutes

Soldering is the process of uniting edges or surfaces of similar or similar metals and alloys, by pa fusion. In general, alloys or sol of various and greater degree fusibility than the metals to joined, are placed between th and the solder, when fused, u the three parts into a solid m less frequently the surfaces or e are simply melted together wit additional portion of the metal.

Sole, the seat or bottom of a applied to horizontal veins or l

Solidity, in geometry, the quanti space contained or occupied solid body, called also its solid tents, estimated by the numb solid or cubic inches, feet, y &c. which it contains

Solids are all bodies that have three dimensions; and among metricians those that are termi by regular planes are called re solids, such as the tetrahe hexahedron, octahedron, do hedron, and icosahedron

Sondelets of iron, used for the dows of St. Stephen's chapel fastenings and cross mullions

Sough, an adit or level for car off water

Sound is produced by a sudden or impulse given to the air: impulses, if quickly repeated, not be individually attended the ear, and hence they app one continued sound, of whic pitch or tone depends on the ber occurring in a given time all continued sound is but a tition of impulses.

The motion of sound throug air is at the rate of about feet per second at the temper of 62°. At the freezing tem ture, when the air is denser, only 1089¾ feet per second. method of determining this vel is to watch the time that between the flash and the

a gun fired at the distance of several miles from the observer. As light travels at the rate of nearly 200,000 miles per second, its passage occupies a portion of time too small to be measured in any terrestrial distance. It may, therefore, be supposed to be seen at the distance of several miles from the observer at the very instant of its production. If, therefore, an observer at one station begin to count seconds on an accurate dial, the moment he sees the flash of a gun at another station, say ten miles off, the number of seconds and fractions of a second which elapse between seeing the flash and hearing the report will give a divisor for the number of feet between the two stations, and the quotient will represent the velocity of sound in feet per second.

All sounds, whatever their intensity, whether the noise of a cannon or a whisper,—whatever their pitch, whether from the diapason organ-pipe or the chirping of a cricket,—and whatever their quality, whether the finest music or the most grating noise,—all travel with the same amount of speed.

When sound from any source is propagated in air, waves are formed similar in character to those which may be so beautifully studied when the wind is blowing over a field of standing corn. Now, when it is said that sound travels at the rate of 1125 feet per second, it is not meant that the particles of air move through that distance any more than the ears of corn travel from one end of the field to the other; it is only the form of the wave which thus travels. So with the particles of air: their individual movement is confined within narrow limits; but the effect of this movement is propagated from particle to particle *with the rapidity of* 1125 feet per *second, which, although* it would be thought very rapid for a motion or the transfer of a body, (being about ten times faster than the most violent West India hurricane,) is yet very slow for the communication or transfer of motion; for, if we pull or push one end of a solid rod, or the liquid filling a long tube, the other end appears to move at the same instant; and although this motion must occupy time, (unless the body were perfectly incomprehensible,) it is much more rapid in these cases than in air, which, on account of its great compressibility, is one of the slowest conveyers of sound. Every one must have observed that vibration can be diffused through a long mass of metal or wood, so as to be heard at a greater distance than through air; but in this case, if the sound be loud enough to be audible through the air also, it will be heard twice, first through the solid, and then through the air. Iron conveys sound about 17 times faster than air, wood from 17 to 11 times, and water 4½ times faster than air.

When waves of sound meet any fixed surface tolerably smooth, they are reflected according to the law of equal angles of incidence and reflection. In this way echoes are produced. Between two parallel surfaces a loud sound is reflected backwards and forwards, and several echoes are audible. Six may be heard between Carlton Terrace and the Birdcage Walk, in St. James's Park, London; fourteen between the steep banks of the Avon at Clifton, and as many under Maidenhead railway bridge. When the parallel surfaces are much nearer together, (as the walls of a room,) although a large number of echoes are produced, they follow each other too rapidly to be distinguished; and as they reach the ear after equal intervals, they produce a musical note, however unmusical the original noise.

have been. Hence all the phenomena of reverberation. The pitch of the note depends on the distance between the two walls which cause it, and may be calculated therefrom.

A noise may also produce a musical echo by being reflected from a large number of equidistant surfaces receding from the ear, so that the sound reflected from each may arrive successively at equal intervals. If we stamp near a long row of palisades, a shrill ringing will be heard. A fine instance of the same kind is said to occur on the steps of the great pyramid. If the distance from edge to edge of each step were 2 feet 1 inch, the note produced would be the tenor c, because each echo (having to go and return) would be 4 feet 2 inches later than the previous one, which is the length of the waves of that note. But as the steps gradually diminish in size upwards, the echo, if produced, and heard at the bottom, must gradually rise in pitch.

Sir Isaac Newton discovered a wonderful coincidence which exists between sound and colours, and proves mathematically that the spaces occupied by the colours in the prismatic spectrum correspond with the parts of a musical chord, when it is so divided as to sound the notes of an octave. So this resemblance may now be considered as extending further, for as in music, so likewise in colours, it will be found that harmony consists in distance and contrast, not in similitude or approximation. Two notes near each other are grating to the ear, and called discords: in like manner, two colours very near each other are unpleasing to the sight, and may be called discordant.

The science of acoustics is little understood, consequently not studied in theory. The want of knowledge of the theory of sound (phonics), in architecture, is a positive evil, and ofttimes of grievous complaint made of our public buildings, after the expenditure of considerable sums of money. Sir John Herschel states, that sounds of all kinds agree in the following particulars: 1. The excitement of a motion in the sounding body. 2. The communication of this motion to the air and other intermedium which is interposed between the sounding body and our ears. 3. The propagation of such motion from particle to particle of such intermedium in due succession. 4. Its communication, from the particles of the intermedium adjacent to the ear, to the ear itself. 5. Its conveyance in the ear, by a certain mechanism, to the auditory nerves. 6. The excitement of sensation. The motion of sound has been demonstrated by Chladin on plates of glass and metal, by strewing sand on their surfaces, and observing the forms it assumed when the sound ceased, the sound being produced on the plate by a violin bow. Sound has been used to discover the nature of disease: by the stethoscope, an instrument similar to a flute tube, physicians ascertain the state of pulmonary disorders, by applying it to the exterior surface of the body covering the lungs. In Chladin's theory, it is stated, that rooms will be favourable to the transmission of sound when arranged to facilitate its natural progress,—when its intensity is augmented by resonance or simultaneous reflection, so that the reaction is undistinguishable from the primitive sound,—when not too lofty or too vaulted,—when there is not a too extensive surface for the sound to strike against at once,—when the seats are successively elevated. He observes, that when the enclosed space does not exceed 65 feet, any form may be adopted for a room; that elliptical, circular, and semi-circular plans produce

prolonged reverberation; parabolic plans and ceilings are the best for distinct hearing; and that for concert-rooms, square and polygonal plans should have pyramidal ceilings, and circular plans domed ones, and the orchestra be placed on high, in the centre, to produce the best effect, and avoid echo. Mr. Robert Mills, an American architect, describes the House of Representatives of the United States' Congress as the most elegant legislative hall in the world: the plan is a semicircle of 96 feet chord, elongated in its diameter line by a parallelogram 72 feet long by 25 feet wide: the height to the entablature blocking is 35 feet, and to apex of the domed ceiling 57 feet, which is pierced by a circular aperture, crowned by a lantern. Besides additional seats and other improvements, a more important object has been accomplished,—namely, rendering the hall a better speaking and hearing room, in which it was before seriously deficient. The voice is now comparatively distinct, and the ear not sensible, except in a few particular points, of any reverberation of the sound: where the voice before was confused and indistinctly heard, it is now full and clear.

Sounding-board, a canopy over a pulpit, intended to diffuse the sound of a preacher's voice through the church

Spalling, in mining, breaking up into small pieces for the sake of easily separating the ore from the rock, after which it undergoes the process of lobbing

Span, or chord of an arch, an imaginary line extending between its springing on each side

Spandril, an irregular triangular space formed between the outer curve or extrados of an arch; a horizontal line from its apex and a perpendicular line from its springing; also a space on a wall between the outer mouldings of the two arches, and a horizontal line or string-course above them; likewise, between similar mouldings and the line of another arch rising above and enclosing the two

Spandril bracketing, a cradling of brackets fixed between one or more curves, each in a vertical plane, and in the circumference of a circle whose plane is horizontal

Spanish Black is a soft black, prepared by burning cork in the manner of Frankfort and ivory blacks; and it differs not essentially from the former, except in being of a lighter and softer texture. It is subject to the variation of the charred blacks, and eligible for the same uses.

Spanish Red is an ochre differing little from Venetian red

Spanshacle, a large bolt driven through the forecastle and forelocked under the forecastle-beam, and under and upon the upper deck-beam; on the forecastle it has a large square ring, for the end of the davit to fix in

Spar, a piece of timber employed as a common rafter in a roof

Specific Gravity of a body is the relation of its weight, compared with the weight of some other body of the same magnitude. A body immersed in a fluid will sink if its specific gravity be greater than that of the fluid; but if it be less, the body will rise to the top, and will be only partly uncovered. If the specific gravity of the body and fluid are equal, then the body will remain at rest in any part of the fluid. If the body be heavier than the fluid, it loses as much of its weight when immersed as is equal in weight to a quantity of the fluid of the same bulk. If the specific gravity of the fluid be greater than that of the body, then the quantity of the fluid displaced by the part immersed is equal in weight to the weight of the whole body. Therefore the specific gravity of the fluid is to that

of the body as the whole magnitude of the body is to the part immersed. The specific gravities of equal solids are as their parts immersed in the same fluid. The specific gravities of fluids are as the weights lost by the same immersed body.

To form a Table of the specific weights of various substances, it is necessary to select one as the standard of comparison: in practice, pure water is always chosen as the starting-point for solids and liquids, and pure atmospheric air for gases, the number 1 (1·000) expressing their specific gravities. The formation of two series is considered to be more convenient than the comparison of all bodies by one standard, on account of the complexity of the numbers which would result.

Solids and Liquids.

Water	1·000
Platinum	21·5
Gold	19·5
Mercury	13·5
Lead	11·45
Silver	10·5
Copper	8·96
Iron, cast	7·2
Iron, rod	7·7
Steel	7·8
Diamond	3·5
Rock Crystal	2·6
Window-glass	2·52
Wax	0·964
Sulphuric acid	1·84
Oil of Turpentine	0·865
Spirit of Wine (strong)	0·83
Ether	0·72

Gases.

Atmospheric air	1·000
Oxygen	1·106
Hydrogen	0·069
Nitrogen	0·972
Carbonic acid	1·524
Carbonic oxide	0·967
Pit gas	0·558
Light gas	0·985

(For the specific gravities of some other substances, see *Data*, &c.)

Spend, in mining, to break work a way

Spere, the screen across end of the hall, in dom ings of the middle ages

Sperver, the wooden frame of a bed or canopy

Sphere, in geometry, a glo contained under one ur face, every point of whicl distant from a point wit the centre of the sphere be conceived to be ge the revolution of a semic its diameter, which is fi called the axis of the spl

Spherical bracketing, the brackets to support lath-a work, so that the surfi plaster shall form the s sphere

Spheroid, a solid body res sphere, supposed to be by the revolution of any an axis

Spheroidal bracketing, the prepared for a plaster cei surface is to form that roid

Spice-plate. At the con Queen Ann Boleyn's dinner, she took wafers a "The table was then tak the Earl of Rutland brou surnap, and laid it at t end, and the Queen wa arose and stoode in the the palace hall: to whor of Sussex, in a goodlie s brought a void of spice fits."

Spiceries and pepper-boxes very large in the Tudor t placed on the high tal shape was that of a tow lated and triple-turre which all kinds of spi placed, of which our were inordinately fond

Spinning-jenny, in mechani chine used in the cotton tories to turn a great spindles, by means of a horizontal wheel

Spinning-wheel, the wheel formerly employed in the spinning of material for textile fabrics: it consisted of a wheel which gave motion to a spindle, on which the thread spun by the fingers was wound

Spira (Latin), the base of a column: this member did not exist in the Doric order of architecture, but was always present in the Ionic and Corinthian; and besides the bases properly belonging to those orders, there was one called the Attic, which may be regarded as a variety of the Ionic

Spiral, in geometry, a curve-line of the circular kind, which in its progress always recedes more and more from its centre. In architecture, a curve that ascends winding about a cone or spire, so that all its points continually approach its axis.

Spire, in geometry, a line drawn progressively round the same axis, with a distance between each circle; a curve-line; any thing contorted or wreathed; a curl, a twist, a wreath. In architecture, it denotes any thing growing up taper; a round pyramid, a steeple.

Spirit of wine, or *alcohol*, is weaker and more dilute than essential oils, or even than water, and is so volatile as to be of use only as a medium for combining oils with resins, &c., as a powerful solvent in the formation of spirit-varnishes, and in some degree as an innocent promoter of drying in oils and colours. In picture-cleaning it affords also powerful means of removing varnishes, &c.

Spirit-level, a cylindrical glass tube, filled with spirit of wine, except a small bubble of air. In whatever position the tube may be placed, the bubble of air will always tend to the highest part of it; but when placed in a perfectly horizontal position, the bubble will remain stationary at the centre of the tube.

Spirketing, the strake wrought on the *ends of the beams of a ship*; where *there are ports, it is the two strakes* worked up to the port-cells; in which case the middle of the planks should not be reduced, unless it occasions the buts to be less than 6 inches

Spital, a hospital

Splashers, screws or guards placed over locomotive-engine wheels (usually faced with brass), to prevent any person on the engine coming in contact with the wheels, and also to protect the machinery from any wet or dirt thrown up by the wheels

Splay, the slanting or bevelled expansion groin, in Gothic and Domestic architecture, to doors, windows, and openings in walls, &c.

Split-pins and cotters, round and flat pins, with a head at one end, and split at the other end. They are used through the ends of bolts, to keep them from getting out of their place, the split end being opened like the letter ⋊, to keep the pin or cotter from falling out.

Spoons. In eating, spoons seem to have been almost the only aid to the fingers at a very early period of our history. "Knives (ancient as they are) were first made in England in 1563, by Thomas Mathews, on Fleet Bridge, London," and were therefore only obtainable, in any considerable number, before that time, by the upper classes of society. Horn and wood were the materials of which spoons were made down to Elizabeth's reign, when pewter became common, and was much improved.

Spray, in navigation, the sprinkling of the sea driven from the top of a high wave in stormy weather

Spring, in mechanics, an elastic body, which, when distorted or compressed, has the power of restoring itself; any active power by which motion is produced or propagated

Spring, in navigation, a rope passed out at one extremity of a ship, and attached to a cable from the other, to bring her broadside to bear upon on an object

Springs, in locomotive engines, the elastic steel supporters of the boiler and frame upon the axles, named after the particular parts to which they apply; as leading-springs for the leading-axle, driving-springs for the driving-axle, trailing-springs for the trailing-axle, tender-springs, drag-springs, buffer-springs, piston-springs, valve-springs, &c., all proportioned to the particular duty they have to perform

Springs.—Water-springs, top-springs, springs of the deep, &c. In contemplating the origin and utility of water-springs, as dispersed upon the face of the earth, for the use of man and beast, and as far deep in the earth as the miner's art has led,—we find much both to inform and amuse those who have not made this subject their study. All springs take their source from the seas, lakes, and rivers: by the heat from that great luminary of our earth, the sun, they are evaporated into the upper regions, and there rarefied, forming clouds filled with rain, which, by attraction and different causes, is plentifully showered upon the earth. It has been urged by some, that it is impossible for rain to supply the copious springs that arise in stony countries, where there is little appearance of a receiving soil, and that rocky ground is impervious to them. But it must be admitted, that if rocks make a discharge of water, they are also capable of receiving it; and that rocky countries are generally as well supplied with springs as others, is well known to all travellers. One of the most stony countries in Europe is Norway, where there is an abundant supply of pure water. It has also been stated that those places where it never rains, both in Africa and some parts of America, are yet well supplied with springs, and at times have flooded rivers. Whence come their springs? The Nile, Niger, &c., are rivers of magnitude, and drain the greatest part of Africa. They replenished with rai receive their immens the extensive mountai lying above and b where they have a weather; and some o annually covered wi well as those district where it seldom rai dews are very prolific that on walking out i or early in the morn the herbage, it is near in this country after rain. Hence it m presumed, that the sp countries are fed by dews, similar to rain i of the world, draw lakes, and rivers, fron tions by the sun du of the day. In thos mates, night and da equally divided. Na perfect in all her wo ing a sufficient perio scent of dews to sup of rain.

It has been likew that the principal s from the sea, and different chasms in th of the earth connec that the water is th divested of its saltne fresh by percolation sand or silt in those then beomes the light superior gravity of t causes it to rise to t the highest hills. Th has proved to be u water of salt-springs so large a portion of by evaporation, pum the coal-pits at Butle and at Newcastle, is r but is of a redder col tains a far larger port But what is still a that those salt-spri connection with th the middle of th

tween Durham and Bishop's Auckland, during the droughty months of summer, when the waters are low, from a rock bottom arises one of the finest salt-water springs known, many degrees salter than that of the sea, surrounded by copious streams of fresh-water; and this place is between 200 and 300 feet above the level of the sea. What syphon-like power could force it to this altitude, so far within the land, from that fancied source? All these kind of springs receive their saltness from passing through beds or mines of salt, such as those at the Wicke, in Cheshire, &c., or some matter yet unknown, of a less dense body, that will more easily communicate its salter particles to the water running through it. What say the inspired writers?—"There is a multitude of waters in the heavens;" and "He causes the vapours to ascend from the ends of the earth:" "He makes the rain." That is, from its seas, its lakes, and rivers, by natural exhalations, the clouds are replenished. "He bindeth up the waters in his thick clouds; and the cloud is not rent under them." "Who hath divided a watercourse for the overflowing of its waters, to cause it to rain on the earth?" The vapours which arise from the sea are much more than sufficient to supply both the surface of the earth and the rivers with water; whilst the mountains, by their particular structure and formation, attract, and, as it were, arrest the vapours and the rain that fluctuate about in the atmosphere; and having collected them in their reservoirs, dismiss them again through their sides, either in perpetual or intermitting currents.

Spring-balance, in locomotive engines, a spiral spring weighing balance, with an index and pointer. This is attached to the end of the lever, by which the pressure upon the safety-valve is adjusted.

Spring-hooks, in locomotive engines, the hooks fixing the driving wheel spring to the frame. A screw on the end of the hook regulates the weight on the driving wheels.

Spring-pins, in locomotive engines, iron rods fitted between the springs and the axle-boxes, to sustain and regulate the pressure on the axles

Springing, the bottom stone of an arch which lies upon the impost

Sprit, in navigation, a small boom or pole which crosses the sail of a vessel diagonally from the mast to the hindermost corner of the sail, to elevate and extend it

Spritsail, in navigation, the sail that belongs to the bowsprit

Sprung, in navigation. When a topmast is broken or cracked near the cap, it is said to be sprung.

Spurs, pieces of timber fixed on the bulgeways, and the upper end bolted to the ship's side above water, for security to the bulgeways

Square, in geometry, a quadrilateral figure with right angles and equal sides. In architecture, an area of four sides, with houses on each side.

Square-rigged, in navigation, an epithet applied to a ship that has long yards at right angles with the length of the deck, in contradistinction to sails extended obliquely by stays or lateen yards

Square sails are such as are extended by a yard, distinguished from others extended by booms, stays, lateens, and gaffs

Square tuck, when the planks of the bottom are not worked round to the wing transom, but end at the fashion-piece

Squaring the circle, in mathematics, is attempting to make a square that shall be equal to a given circle

Squinch, a term applied to small arches or projecting courses of stone formed across the angles of towers

Squint, an opening through the of a Roman Catholic church, oblique direction, for the

of enabling persons in the transept or aisle to see the elevation of the Host at the high altar

Stadium, a Roman measure of length, nearly equivalent to our furlong. The term was also applied to a building, or an enclosed area, in which gymnastic and athletic exercises, chariot-racing, and foot-racing, wrestling, and other public games, were exhibited. The stadium was divided into distances for the racers. Also a Greek structure, of an oblong area, terminated at one end by a straight line, at the other by a semicircle, having the breadth of the stadium for its base. Around this area were ranges of seats rising one above another, erected for the purpose of witnessing the public sports at Olympia and other places.

Staircases. It was in the reign of Elizabeth that staircases first became features in English houses. Hand-rails and balustrades, unlike the rickety contrivances of modern days, were of gigantic proportions, and presented at once a bold, picturesque, and secure appearance; yet so variously and fancifully decorated, that their effect was always pleasing and free from clumsiness. In the middle of Verulam House was a delicate staircase of wood, which was curiously carved; and on the posts of every interstice was fixed some figure, as a grave divine with his book and spectacles, a mendicant friar, &c. In two of the principal chambers of Wressil Castle are small beautiful staircases, with octagon screens, embattled at the top, and covered with very bold sculpture, containing double flights of stairs, winding round each other, after the design of Palladio. The east stairs at Wimbledon House lead from the marble parlour to the great gallery and the dining-room, and are richly adorned with wainscot of oak round the outsides thereof, all well gilt with fillets and stars of gold. The steps of these stairs were in number 33, and 6 feet 6 inches long, adorned with 5-foot paces, all varnished black and white, and chequer-work; the highest of which foot-pace is a very large one, and benched with a wainscot bench, all garnished with gold.

Staircases, in ordinary modern practice, should be light, spacious, and easy, seeming to invite people to ascend. Principal staircases should not be narrower than 4 feet, so that if two persons meet thereon, they may pass each other with convenience; but they may be extended in breadth to 10 or 12 feet, according to the importance of the building. The steps should never exceed 6 inches in height, nor be less than 4 inches; but this latter height is only allowable in very wide staircases. The breadth, or the flat horizontal part, which is called the tread of the step, should not be less than a foot, nor exceed 15 inches.

Stakes, in ship-building, are the regular ranges of planks on the bottom and the sides of the ship, reaching from the stem to the stern

Stall, a place occupied by a monk, canon, dean, or prebendary, in the choir of a church; sometimes applied also to the sedilia or presbyteries for the officiating ministers; in the wall of a chancel

Stamps, machinery for crushing ores

Stanchion, in ship-building, a small pillar of wood or iron, used to prop and support the decks, awning, &c.

Stanchion, the upright iron bar between the mullions of a window, screen, &c.

Standards, timbers in the form of knees, with one arm on the deck, and the other fayed to a ship's side

Stantients, the upright pieces in a bulk-head, breast-work, &c. of a ship

Starboard, in navigation, the right-hand side of a ship, looking forward, as larboard is the left-hand

Starlings, in architecture, are large piles placed on the outside of the foundation of the piers of bridges, to break the force of the water and protect the stone-work

Statics, the science which considers the weight of bodies, or the motion of bodies arising from gravity

Stations, a generic term applied to fixed points or places, of which a series is included in any extended works or arrangements. Thus we have Post-office Stations, Telegraph Stations, Police Stations, Fire-engine Stations, and Railway Stations.

As applied to railways, the term station is a very comprehensive one, comprising a multitude of buildings and apparatus of an extended and costly character. Terminal stations of long lines of railway usually cover several acres of ground, and include buildings for the assembling of the passengers, and for classifying them in separate compartments, according to the class of carriage they intend to occupy; extended platforms, conveniently arranged for the arrival and departure of the trains, and well protected from the weather, and lighted by night. The level of these platforms is arranged so that persons walk directly into the carriages, without ascent or descent, and their length is sufficient to serve many carriages, or two or more entire trains at one and the same time. A separate department of the station is usually allotted to the receipt, arrangement, and distribution of parcels and goods of all kinds, from bulky bales and ponderous hogsheads down to a packet of such insignificant dimensions that it may hold no more than a half-ounce letter. The goods' warehouses belonging to this department are of great size, and fully furnished with cranes and moving and weighing gear of all requisite powers and dimensions, fitted to load and unload the goods'-waggons belonging to the line, and all ordinary road vehicles. Besides these purposes, the terminal and first-class stations often include a complete engineering establishment of a practical character, in which the locomotive engines, carriages, trucks, waggons, &c., are repaired and built, and including foundry, smithies, pattern-turning, fitting, erecting, and repairing shops; the latter being provided with rails below for running the engines into the building, and travelling cranes above for lifting them entire when needed, or aiding in their dissection with all the rapidity and delicacy of movement which commonly belong only to operations upon far smaller and easier handled subjects. The station also embraces ample buildings or engine-houses in which the locomotive engines are ranged like so many post-horses in a road-side stable, ready for immediate action, and in which the raking out of fires and the cleaning and adjustment are daily performed. Complete arrangements are also included for delivering water and coke to the tenders, and in some the necessary buildings and apparatus are comprised for pumping the water from deep wells, for burning the coke, and even for manufacturing the gas to be employed in the lighting of the whole of the buildings and shops. Board-rooms, clerks'-rooms and offices, and residences for the station-master and assistants, besides store-rooms of all kinds, refreshment-saloons, urinals, water-closets, police-rooms, telegraph-rooms, lost-luggage office, &c., &c., are also among the necessary details of a principal railway station. The area of the station is covered with lines of railway for the passage of the engines and carriages, and provided with turn-tables, revolving and traversing, for readily transferring the carriages from one line to another, besides switches and apparatus for

connecting the several lines at intervals. Of the extent of some of these works at one of the metropolitan stations, that at Camden Town, on the line of the North Western Railway, the following particulars will convey some idea:—This station, which is chiefly for goods only, covers an area of 30 acres, and has a length of double line of 2500 feet for the goods' waggons only, and entirely clear of the main line. The length of single line of railway, exclusive of the main lines, exceeds 12 miles. There are 112 sets of points for turning carriages from one line to another, 196 turn-plates, and 110 cranes, varying in power from 1½ to 20 tons. The area covered with goods' sheds exceeds 135,000 superficial feet, and that of the platform is 30,000 feet. The circular engine-house is 160 feet in diameter, and will contain 24 engines and tenders; the central turn-table within it is 41 feet in diameter. The annual consumption of gas exceeds six millions of cubic feet.

In minor or intermediate stations, the works are, of course, of smaller magnitude, and are not required to subserve all the combined purposes of a principal station.

Stations for railways, of an inexpensive yet neat character of construction, are erected on the Taunus Railway, running parallel with and being in the vicinity of the Taunus mountains between Francfort on the Maine and Wiesbaden. The line runs through three different territories:—1st, commencing in and running through part of Francfort; 2nd, through part of the Duchy of Nassau; and 3rd, through the Grand Duchy of Hessen Darmsdadt, for a short distance going through the fortress at Castel; and, lastly, entering Nassau again. The total length is 27 English miles. There are six intermediate stations, viz. Höchst, Hattersheim, Flörsheim, Hochein, Castel, and Biebrich. The capital of the company and cost of the line, including purchase of land, stations, locomotive power, machinery and plant, and workshops, was £275,000; the absolute outlay, £263,286. 9*s*. 11*d*. The separate cost of the several stations and houses, and watch-houses, was £26,513. 10*s*. 2½*d*., including the station-house in Francfort, which is a large stone building, being a pavilion with two wings, and at the end of each wing is a small pavilion. The large or middle building contains, 1st, ground-floor, the booking-clerks' offices, where the tickets are given out and money taken; 2nd, in first story, the sitting-room for directors, where their meetings are held, and acting-director's offices, with office for head cashier and secretary. The attics are used as lumber-rooms and store-rooms for articles which are left behind. The right wing is used for waiting-room for first, second, and third class passengers, being very well decorated,—mahogany sofas, with horsehair seatings, running round the walls; the windows having beautiful chintz curtains, and the roof or ceiling being tastefully decorated. At the end of this wing is a small pavilion two stories high; the ground-story being used as offices and store-rooms for luggage and goods' transport, the upper-story as dwelling for foreman and clerk. The left wing is used as waiting-room for the fourth-class passengers, being as large as the other, but quite plain, the seats being of oak. The pavilion at the end is used for steam-boat offices, &c., on ground-floor, and the upper story as a dwelling for the station's overseer. The station-houses at Castel and Wiesbaden are very similar to the above, except that the Castel station-house is built of wood, and has a covered passage, used on

in bad weather, between the waiting-rooms and carriages. The intermediate stations are merely large enough for the clerks to live in the upper stories, the under parts or ground-floor being used as waiting-room and clerk's office. The passenger-sheds are all splendid buildings, being three in number upon the main line, and one at Biebrich, of wood; but from their neat construction and decoration deceive the eye at once into believing they are made of more solid and substantial materials. The dividends of this railway have produced a return varying from 10 to 12½ per cent.

Statuary, a carver of images or representations of life; one who practises or professes the art of sculpture.

Staves, in joinery, the boards that are joined together laterally, in order to form a hollow cylinder, cylindroid, cone, or conoid, or any frustrum of these bodies. The shafts of columns, in joinery, are frequently glued up in staves.

Stay, in navigation, a strong rope employed to support the mast in the fore-part: *to stay* a ship, to manage the sails so that she shall not make any way forward, preparatory to her tacking about

Staysail, in navigation, a sort of triangular sail extended on a stay

Stays, outside, in locomotive engines, sling-stays binding the boiler and frame together

Stays, inside boiler, in locomotive steam engines, rods of iron binding together the flat ends of the boilers. The flat side of the dome is likewise strongly bound together by iron rods. Without these stays, they could not resist the pressure of the steam against so large a surface.

Stays, inside frame, in locomotive engines, strong stays placed below the boiler, firmly fixed at one end *to the fire-box, and* at the other *end to the smoke-box*: they support the inside bearings of the driving axle and other parts of the machinery

Stay-wedges, in locomotive engines, wedges fitted to the inside bearings of the driving axles, to keep them in their proper position in the stays

Steam, the vapour of hot water at the boiling point of 212 degrees

Steam-chest, in locomotive engines, a box attached to the cylinders, into which the steam is admitted by the regulator: the slide-valve works in this box over the steam-ports, which open into it from the cylinder.

Steam-chest cocks, in locomotive engines, oil-cups, placed conveniently for lubricating the faces of the steam-ports and slide-valve

Steam compression. The steam which has performed its duty in the cylinder, but which has not escaped before the slide-valve closes the exhaust-port, is compressed by the advancing piston. This compression begins, according to the lap and travel of the slide, from 2 to 3 inches from the end of the stroke, and is of considerable amount. It is, however, of advantage in checking the momentum of the piston, and relieving the strain on the connecting and piston rods at the end of each stroke, and is not therefore all lost power.

Steam Engine, a machine for deriving power from the expansion which results from the conversion of water into vapour or steam by the application of heat. This expansion is so great that a given quantity of water becomes, when changed into the form of steam, enlarged to about 1728 times its original bulk; and this expansion takes place with a force that may be termed irresistible. Thus if water be enclosed in a vessel, say of iron or any other strong material, and the water be expanded into steam, and insufficient space left for the expansion, the vessel will be burst by the force of the steam within. A steam engine con

sists essentially of a vessel into which the steam is admitted, and which is provided with a moveable disc, closely fitting the interior and capable of sliding within the vessel. This vessel is made cylindrical, because this form gives the greatest strength and is the most readily fitted with the moveable disc. The vessel is termed the *cylinder*, and the disc the *piston*. Supposing the cylinder to be placed upright, and fitted with a close cover, and that while the piston is near the bottom of it steam is admitted to rush in through a pipe below the piston, the piston will be driven up by the steam, and if, when it reaches the upper part of the cylinder, the steam from below is shut off, and admitted through an upper pipe to press upon the top surface of the piston, it will be forced down again. Thus a rectilinear motion up and down is produced, and this constitutes what is called the *principle* of the steam engine. All its other parts are for the purpose of regulating the admission of the steam, and converting the rectilinear motion produced at the cylinder into a rotary motion at the point where the power is required to be applied for working machinery. The steam, when no longer required for that purpose, is allowed to escape into the open atmosphere, or conducted in a pipe to another vessel, which, being cooled by the application of cold water, rapidly condenses the steam, that is, reconverts it into water. If permitted to escape into the air, the steam has to force itself against the pressure of the atmosphere, whereas if conducted into a condenser, this force is not required. Hence steam of less pressure will work what is termed a *low-pressure* or *condensing engine*, while that already described is for distinction called a *high-pressure engine*. A third variety of steam engine is worked by shutting off the steam before it has driven the piston the whole length of the cylinder, or completed the *stroke* termed, and the subse pansion of the steam con impulse upon the piston. thus worked are disting *expansive engines*. The difference in the mechani densing and expansive stea is in the movement of the which admits and shut steam, or the *valves*, wh doors within the pipes. T parts of a condensing engi appliances are as follows *boiler*, in which the stea duced from water by the fire in the furnace beneat the *steam-pipe*, in which is conveyed to the engin the *steam-chests*, in which is received, and which com with the two *induction-p* lead into the upper and l of the cylinder; 4thly, th fitted with the *piston*, a pipes, called the *educ* through which the stea away when its work in th is completed, into the c 5thly, the *air-pump*, which the water formed by the steam, sending it into t producing a partial vacu the condenser, and thus the escape of the steam cylinder; 6thly, the *con* self, which is kept cool w pumped up by the cold-wa The piston has a rod fi which works through a st opening or *stuffing-box* in the cylinder, and this *pis* attached to one end of which turns upon a centr other end of which worl *necting-rod* attached to a the side of which a rotar is thus imparted. In som the piston-rod is connecte directly with the crank, a are hence termed *direct-act* engines, while the former tinguished as beam-eng others, again, the pi

attached to the crank without links, and the cylinder, instead of being fixed, is made to vibrate or oscillate: these are therefore termed *vibrating* or *oscillating engines*. *Marine engines* for propelling vessels on the water, and *locomotive engines* for propelling trains of carriages upon railways, are each distinguished by peculiarities of construction and arrangements, fitting them for their especial duties.

Steam exhaust-port, in the locomotive engine, the passage opened below the slide-valve from the cylinder to the atmosphere. It is placed between the two steam-ports, and is nearly twice their area, the more freely to permit the escape of the steam. It is open to the blast-pipe, and is cut off from any communication with the steam in the steam-chest by the slide-valves. The arch part of the slide-valve opens the passage from the cylinder into the central exhaust-port, where, through the blast-pipe and chimney, it escapes to the atmosphere, and by this means produces the draught on the fire.

Steam-gauge, a contrivance to show the exact amount of pressure of the steam; it consists of a syphon-tube with equal legs, half-filled with mercury: one end is cemented into a pipe which enters that part of the boiler which contains the steam; the other end is open to the atmosphere. A stop-cock is usually provided between this gauge and the boiler, so that it may be put in communication with the boiler at pleasure. When the stop-cock is open, the steam acting on the mercury in one leg of the gauge presses it down, and the mercury in the other leg rises. The difference between the two columns is the height of mercury which corresponds to the excess of the pressure of the steam in the boiler above the pressure of the atmosphere; or, in other words, to the effective pressure on the safety-valve. If half a pound per inch be allowed for the length of this column, the effective pressure of the steam, in pounds per square inch, is obtained.

Steam Navigation. This is accomplished by the application of steam power to the *marine engine*, by which vessels of all dimensions are propelled on the waters of the ocean or on the principal rivers. Whether by means of the paddle-wheel, or by the spiral or helix screw, the fluid is displaced and the vessel sent forward at the various speeds consequent upon the skill employed in the making of vessel and engine. Much competition and many controversies have existed upon the best methods to be adopted. Many instances of failures have occurred from the simple circumstance of the builder of the ship and the constructor of the engine not acting in concert. Steam vessels for river-passenger traffic, when in trim and all their parts well constructed, average a speed of 15 miles an hour; in America 18 miles; and sea-going vessels average on their way 12 miles: Cunard's packets from Liverpool to Halifax and Boston have done more. The West India, Peninsular, and Oriental Companies have splendid vessels, which do credit to the companies for their enterprise,—to the builders for the construction of the craft, and to the engineers for the construction of the engines. Other companies exist who deserve their proportion of praise. It is to England and Scotland that the world is indebted to for this new element of civilization.

Steam-pipes, in locomotive engines, the pipes which collect and convey the steam to the steam-chest: they commence inside the boiler. In boilers with domes, the receiving pipe is raised as high as possible, and turned back round the edges of the open end, to prever

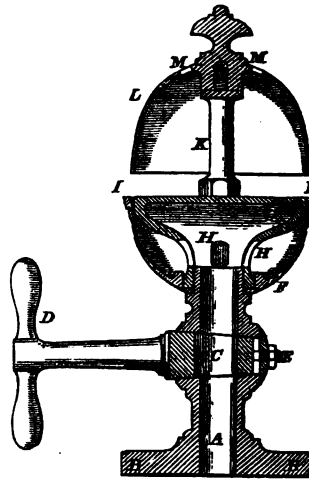
any water which might rise so high from overlying the pipe. In boilers having no domes, the steam is collected in a horizontal pipe pierced with numerous small holes. After being collected, the steam-pipes are continued outside the boiler to the steam-chest. The internal diameter of the steam-pipe is usually rather more than one-fifth of the diameter of the steam cylinders: the area of the passages through valves, in some of Watt's beam engines, is nearly one square inch per horse power. This is in some cases too large for steam-passages, but rather too small for the exhausting valve-passages.

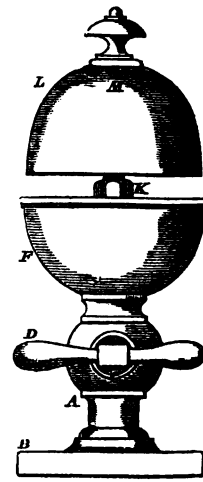
Steam-pipe for tender, in locomotives, a small pipe attached to the boiler by a cock, for admitting the spare steam to heat the water in the tender

Steam-ports, in locomotive engines, two passages from the steam-chest to the cylinder. The steam is admitted to and from these passages by the slide-valve opening the port for the admission of steam to the cylinder, and then by shutting off this port from the steam in the steam-chest, and, opening the same passage by which it entered, it is conveyed to the atmosphere.

Steam-whistle, an apparatus attached to the boiler of a locomotive engine for the purpose of giving warning of its approach when running. The construction of the whistle is shown to one-quarter size in the annexed engravings. It is made of brass, and the foot, A, is cast hollow, with a flanch, B, at the bottom, to bolt it on the fire-box: it has a cock, C, placed in it, with the handle D, and screw E, to keep it tight; the handle projects out, to allow firm hold to be taken of it. The cup F is fixed upon the foot A, by screwing the piece G upon it, and both are turned truly at their outer edges, leaving a very narrow passage, I I, *four* inches diameter, between them *all* round. The piece G is hollow, having holes, H, in its sides; and a pillar, K, stands upon its centre, on which is screwed the bell, L L, the thin edge of which is brought just over the opening I, and half an inch above it.

When the cock is opened, the





steam enters the cup F through the holes H, and rushes out at the narrow slit I, striking the thin edge of the bell, L, in a manner similar to the action in organ-pipes, and producing an exceedingly shrill and piercing sound. Some holes, M, are made in the top of the bell, to allow the steam to pass through, which improves the sound considerably. The size of the concentric part where the steam escapes, and the depth of the bell part, and their distance asunder, regulate the tones of the whistle, from a shrill treble to a deep bass. The cock should be steadily opened, to adjust the quantity of steam, so as to produce the clearest sound. The steam-whistle is very effective, and its sound can be heard at a great distance.

Steel is composed chiefly of iron and carbon; yet these alone will produce but a poor and brittle article. Good steel contains a variety of elements, almost all of those, in fact, which are considered impurities of iron when present in excess.

Steel is divided into four distinct classes,—Damascus steel; German steel; Blistered, or blister steel, to which class shear steel belongs; and Cast steel. The first is made directly from the ore, or by welding steel rods and iron rods together; the second from pig metal, by depriving the latter of a portion of its carbon and impurities; the third from bar iron, by impregnating it with carbon; and the fourth class, or cast steel, may be made from either of the others, by melting it in a crucible. Still, blistered steel appears to be the most advantageous, so far as quality is concerned.

Damascus Steel.

This steel derives its name from Damascus, a city in Asia. The swords or scimitars of Damascus present upon their surface a watery appearance, a variegation of streaks of a silvery white, black, and gray colour, and fine and coarse lines, exhibiting regular and irregular figures. The excellent quality of these blades is proverbial: they unite hardness to great elasticity. Genuine Damascus steel is made directly from iron ore; and meagre as our knowledge is concerning the subsequent manipulations, such as forging and hardening, it is known that the steel is smelted, in a kind of Catalan forge, from red oxide of iron, a red clay ore found in transition slate. It is generally believed that the great strength of this steel is to be attributed to a small quantity of aluminum which enters into its composition, and which is derived from the clay of the ore,—an opinion which has this fact in its favour, that no material imparts a greater degree of tenacity to iron than alumina. Great exertions have been made to imitate this steel, in which, of all nations, the French have been the most successful. They have succeeded in imitating not only irregular figures, but arabesques and initials, in the most beautiful manner. Still, the French is far less tenacious and hard than the genuine Damascus steel. The virtue of the latter, therefore, must be sought for in the ore from which it is made.

German Steel.

This steel is made in two different ways, either directly from the ore, or by converting the ore into pig metal, and then into steel. The steel manufactured by the first method is generally crude and irregular, and therefore this method is seldom practised.

The Stück oven, or Wulf's oven, as well as the Catalan forge, is one of the furnaces employed in the manufacture of steel from ore. In making steel, the blast is directed more upon the fuel than upon the iron: the tuyère is level: the iron is impregnated with carbon. The re-

verse is the case in the manufacture of iron. In the blue-oven, a kind of pig metal is frequently made, which is almost pure steel; but it is coarse, and never, even after the best refining, makes a good article. All manipulations, the object of which is to make steel directly from the ore, are unprofitable.

To this class belongs the manufacture of wootz, or East Indian steel. This is certainly a good steel, and is partially imitated in America. Wootz is smelted directly from the ore, which is the black magnetic oxide of iron, in furnaces five or six feet high, of the form of some foundry cupolas. Previously to smelting, the ore is finely pounded and washed, to remove impurities.

The manufacture of steel from pig metal does not depend so much upon the manipulations in the forge as upon the quality of the metal. The ores generally employed are the crystallized carbonate, spathic ore, often mixed in a slight degree with hematite, and the rich red peroxides. Magnetic ores do not answer for such work, and are therefore but seldom used. The same may be said in relation to the hydrated oxides. Pig metal for steel manufacture is smelted with as little lime or other flux as possible. The principal flux to be relied on is manganese; but this always exists in the ore, and is never used as an artificial admixture, though it is possible that an artificial flux might be made of it. Steel metal is in most cases white. It is smelted by rather more ore than that which will make gray iron; but not with so heavy a burden as that which will make white iron containing carbon in small amount. Any ore which contains foreign matter in such large amount as to make the addition of lime as a flux necessary, does not make good steel metal. The only mode of working the furnace is, of course, by means of charcoal and the employmen the cold blast.

The forge fires employed in c verting the metal into steel do differ materially from those in wh iron is made. The hearth of former is generally larger deeper, and the blast is stro than that of the latter. Very li iron is connected with it. bottom is generally formed of sa stone, and the sides of brasse, charcoal-dust mixed with clay. practical manipulation at th forge-fires varies according to lo lity, to the form of the furnace, the qualifications of the workm The main principle involved be generalized under the follow proposition: If it is intended make steel instead of iron, metal should be melted before off from the tuyère; and it sho be kept, when melted, always low the blast, and never brou above or into the blast. By attention to locality, every thi else may be easily regulated. skilful workman will soon ascert that a flat hearth, an iron lini and a strongly dipped tuyère not make steel, though it will ma iron, and that a weak blast tend to produce iron.

The crude steel, the result of first operation, is generally throw when red-hot, into cold water, th broken and sorted. The most very part, of the finest grain, is best. Fibrous or partially fibr bars are reserved for iron: th make a superior quality of bar ir Bluish-looking steel is also thro aside, for it will become fibr iron before its impurities can removed. The crude steel, dra out into bars an inch or an in and a quarter square, is placed piles composed of six or eight piec then welded, and drawn out in smaller bars. This process, call refining, is repeated three or fo times, and each time the num of bars in the pile is incre

The smaller the bars of steel, and the greater the number of them placed together, the more perfect will be the refined steel. The piles are heated in a large blacksmiths' fire, by stone coal, which must be sufficiently bituminous to form an arch over the fire. Coal-slack, mixed with loam, is frequently used for this purpose; but it increases the waste of steel. The hammer used for drawing steel should be light, weighing no more than 150 pounds, and ought to make from 300 to 400 strokes per minute. Great skill and dexterity are required to draw steel bars. It is highly important to perform this operation well, as the quality of the steel is, in some measure, dependent upon the manner in which it has been hammered.

In those countries where German steel is made, a remarkable article is manufactured, which deserves notice. It is harder than the best cast steel, but so brittle that it cannot bear any bending when cold. This article is cast iron: it is derived from the re-melted steel metal. From 200 to 250 lbs. of this metal are generally melted. When that quantity is melted down in the bottom of the forge-hearth, a small portion of it is let off: it should be tapped as low at the bottom as possible. This mass, which flows like cast iron or cast steel, is broken into small pieces, and pounded into a flat piece of wrought iron, which has a brim drawn up around it: this piece serves as a crucible. It is covered with loam, and exposed to a heat which will melt the cast iron, and unite it firmly with the wrought iron. The former then forms a thin coating of steel over the one side of the iron, of immense hardness. This does not become soft, even though a long time is consumed in tempering it. *Wrought-iron plates, furnished with such a coating of steel, are used as draw-plates for wire.* The holes for the wire are punched when it is warm; for, when cold, its hardness is so extreme, that no drill-bit can make any impression on it.

Iron for Blistered Steel.

England is not so celebrated for the production of iron suitable for the manufacture of steel as Sweden and Russia, upon which countries we must depend mostly for our knowledge of the mode of working it, and the kind of materials from which iron for the steel factories is made.

The peculiarities of such iron are so remarkable, that, by means of the most accurate chemical analysis, we cannot detect any difference between a given kind which produces a superior, and another kind which produces an inferior steel. Were it possible to detect this difference, it would prove to exist in the cinders. The iron from which blistered steel is made is a soft, fibrous, often grained, wrought iron, of a peculiar silvery whiteness. It is made from mottled pig iron, smelted from magnetic ore by charcoal and cold blast.

In making pig iron for the manufacture of steel, the ore should be carefully roasted by wood, charcoal, or braise. The height of the blast-furnace must not exceed 35 feet, and the result is still more favourable when it does not exceed 30 feet. The boshes should measure about 9 or 9½ feet. There ought to be either no hearth at all, as in the Swedish or Styrian furnaces, or one that is very low. Blast of medium strength, and tuyères somewhat inclined into the hearth, are requisite. Hot blast must be rejected altogether. In fact, the operation should be conducted in such a manner as to produce mottled iron of great purity. In fluxing the ore, lime can be employed, but only in such limited

quantity as not to cause the furnace to smelt gray or white iron; for neither will be serviceable in the manufacture of good steel.

In converting pig into bar iron, the German forge is generally employed in Sweden, and for this purpose may be considered the most perfect. The refining process resembles the boiling of iron: this is required to make the texture of the iron as uniform as possible. White pig metal will not boil, and it works too fast. Gray pig metal contains a large amount of impurities, and the greatest attention at the forge will not remove them in sufficient amount to answer any practical purpose.

In making blistered steel, it is essential to consider not only the quality, that is, the chemical composition of the iron, but also its form. The bars are generally flat: good qualities are from an inch and a quarter to two inches in width, and half an inch thick. For ordinary steel and for cast steel, the thickness of the bars may be three-quarters of an inch; but in these cases, more time is not only required in blistering, but the heart of the bar is still imperfectly carbonized. Thin bars work faster, and make a more uniform steel than thick and heavy bars: the latter are always more or less raw inside, and contain too much carbon outside. If the iron is very pure, it may be short, that is, without fibres: it may be hard, if it is at the same time strong. Impure iron will not make steel of good quality. As iron void of fibres is generally more impure than that containing fibres, the safest plan is to convert all the iron into fibrous iron. Coarse fibrous iron, whatever may be its strength, does not make good steel: that with black spots or streaks of cinder must be avoided by all means. The indications of a good iron are, a silvery-white colour, short fine fibres, a bright metallic lustre, and an aggregation so uniform, that black spots cannot be detected with a lens. The transformation of bar iron into steel requires no special skill or knowledge. The quality of the steel is determined by the quality of the iron from which it is manufactured.

Blistered Steel.

The furnace for the conversion of wrought iron into blistered steel is from 12 to 15 feet wide, and 20 or 25 feet deep. A conical chimney, 40 or 50 feet high, is designed to lead the smoke above the roof of the factory. The iron is placed in boxes composed of fire-brick or sandstone tiles: these boxes are from 24 to 36 inches square, and from 10 feet to 16 feet in length. Square holes at one end of the furnace serve for the admission of the iron, and the entrance and exit of the workmen. Holes are also made in the ends of the boxes, through which one or more of the bars may be passed, for the purpose of testing the degree of cementation, and the progress of the work. The boxes are enclosed in the furnace, which is provided with a grate and fire-brick arch. The iron, when placed in these boxes, is imbedded and carefully laid edgewise in a cement composed of one part hard charcoal, one-tenth part of wood ashes, and one-twentieth part of common salt. The mixture is ground into a coarse powder under edge-wheels. If the boxes are 10 feet in length, the iron bars may be 9 feet 10 inches. The cement is laid about 2 inches deep in the bottom of the box. The bars of iron are then put in edgewise, separated by ¾ of an inch space, which is filled with cement, and the top of the bars covered to the depth of ½ an inch. Upon this another layer of bars is set, but in such a manner that the second layer overlies the space which separates the bars of

the first layer. In this way the box is filled to within 6 inches of its top. The remaining space is filled with old cement powder, on the top of which, finally, damp sand or fire-tiles are placed. The fire ought to proceed slowly, so that three or four days shall elapse before the furnace and the cement boxes assume a cherry-red heat. In fact, the fire should be conducted in such a manner that the heat may be slightly increased every day during the whole course of the operation. A diminution of the heat, from the time of starting, occasions a loss both of fuel and time, and is injurious to the chests. A well-conducted heat will finish a small box in four or five days, and a couple of boxes, 3 feet square, in ten or twelve days. The furnace and boxes should be cooled very slowly; for a sudden change of temperature is very apt to break the fire-tiles, or sandstone slabs, of which the boxes are constructed. The trial-bar, which passes through the small hole in one of the ends of the box, and in a corresponding hole in the furnace wall, is somewhat longer than the other bars, so as to be taken by a pair of tongs, and pulled out of the box. There are frequently several of such bars, for a bar that is once pulled cannot be returned; and if, in a case in which there is but one trial-bar in the chest, the bar is pulled too soon, no further opportunity of testing the progress of cementation is afforded. The trial-bars are not sufficiently long to project over the wall of the chest. The trial-hole is closed by a clay stopper. Six days may be considered a sufficient time for blistering bars of common steel, such as spring steel, saw-blades, and common files; eight days for shear steel and steel for common cutlery; and ten or eleven days for the better qualities of steel, and *common cast steel.* Rods for the *finer sorts of blistered,* and the finest kinds of cast steel, are returned to the boxes after the first heat, and receive two or three blistering heats, according to the quality of steel wished to be obtained. From eight to twelve tons of iron may be charged in two chests, and from four to eight tons in case the furnace contains but one chest. Two small chests are preferable to one large chest. The smaller the chest, the more uniform will the steel become. The regulation of the fire in the furnace is a somewhat delicate operation. Iron of different qualities requires a different degree of heat; but the heat can be easily managed by recollecting that it should be steadily increased every day. If it is not sufficiently strong, the iron will absorb but very little carbon, and the work will proceed slowly. If the heat is too great, the rod iron will be converted into cast iron, or, at least, into something similar to it; for, after being once overheated, it will not, even with the greatest labour and attention, make good steel. If the heat is carried so far as to melt the blistered iron in the boxes, it is converted into white plate-metal,—the kind from which German steel is manufactured. But this melting cannot well take place, and if it should occur, the slow cooling of the chests, which is equivalent to tempering, will transform the white metal into gray cast iron. The latter is converted into steel with greater difficulty than the white metal.

Blistered steel, taken from the chest, is very brittle: the excellence of its quality is in proportion to its brittleness. The presence of fibres indicates that the cementation is unfinished. A fine-grained, white aggregation, like iron rendered cold-short by phosphorus, indicates that the cementation has not advanced beyond its first stages. A crystalline form of the grains is an indication either of imperfect or

mentation, or of too low a heat, or bad iron; still, the best kind of iron will exhibit these crystals, and they can be observed by the lens, if the temperature of the chests has not been kept sufficiently high. If a good article be desired, a repetition of the operation is, in such cases, necessary. The grains of good steel appear like round globules, when taken from the chest and broken. After an imperfect cementation, the colour of the steel is white. Good blistered steel should be of a grayish colour, and of a bright lustre; and it should exhibit a coarse grain, as though it were an aggregation of mica or leaves of plumbago. That which exhibits a fine grain, of crystalline form, and which is of a white colour, is always a poor article. But one degree of heat is favourable for each kind of iron: if that degree be hit upon, the operation goes on well; if otherwise, a favourable result cannot be expected. The composition of the cement and the construction of the boxes and furnace have little influence on the quality of the steel. Where the iron is of the best quality, and where the degree of heat is most favourable, the fracture of a bar taken from the chest will exhibit the largest grains or leaves. An indication of good iron is its increase of weight in cementation: while bad iron neither gains nor loses in weight, iron of good quality will gain at the rate of from 15 to 20 per cent. This applies especially to strong and pure iron. The surface of the rods, whatever mumber of blisters they may have when taken from the chest, must be clean. Bad iron makes but few blisters, or none at all: the surface of the rods is rough. With the quality of the iron the number and size of the blisters increase. *Danemora* iron draws blister close to *blister*, and almost all of equal size. *Common* iron, that is, charcoal *iron*, raises but few blisters, and these are of irregular size. The best qualities of puddled iron raise but few blisters.

As might be expected, the texture and quality of one bar, as well as the average which a chest contains, cannot be uniform. The interior of a bar, like the interior of the box, will be imperfect, while the external parts will be overdone. The steel should, therefore, be broken, assorted, and refined. Pieces of uniform grain, as well as those including the extremes of quality, are piled, welded, and drawn out into bars. This process must be repeated, if the grain is not sufficiently uniform for the desired purpose. Upon the skill of the hammer-man the quality of the steel, in a considerable degree, depends. Slow and heavy strokes and high heats depreciate its value, while its quality is improved by a low heat and fast work. Rolling steel in a rolling-mill, or welding it in a reheating furnace, makes it brittle, and transforms it into a kind of cast iron. This result, however, can be partially remedied by again bringing the steel to the hammer.

The influence of the tilt-hammer upon the iron is no where more observable than in the manufacture of steel. It is impossible to make good steel independently of proper hammer machinery. The temperature at which the hammering should be performed is a matter of considerable importance: the steel will be spoiled equally by a too high as by a too low heat. The secret of success appears to be the prevention of crystallization, which takes place at certain temperatures of the metal. Under favourable conditions, definite compounds of carbon and iron are formed; and these compounds crystallize: this crystallization causes brittleness. The greater the amount of foreign matter which is combined with the iron, the greater the brittleness. Blows of the hammer quickly re-

peated, and the exposure of the metal a short time to a low heat, appear to be the means of preventing crystallization,—at least, of diminishing its extent. A sudden change of temperature augments the power of crystallization in the highest degree. This makes the iron hard, by giving rise to so strong an affinity between the iron and foreign matter, that the colour occasioned by the carbon disappears. The carbon is enclosed in the particles of iron, which is, in turn, crystallized by means of its strongly cohesive properties. White plate-metal of great purity, containing carbon in large amount, is harder than the hardest cast steel, but the strength of its cohesive properties, and the larger size of its crystals, are the causes of its brittleness. The best steel, if melted at a high heat, similar to that of the blast-furnace, would appear in the same form as plate-metal, and would be quite as brittle. From the facts here stated, a conclusion may be drawn, that the impurities which increase the cohesive power of steel or iron may be retained, and the formation of crystals still be prevented.

Cast Steel.

The irregularity exhibited in the texture of common steel gave rise to the invention of cast steel. Common steel is broken into small pieces, and closely packed into a crucible made of good fire-clay. That which is in some degree more highly carbonized than usual is best adapted for cast steel; because, in the melting operation, it loses a portion of its carbon. With the fire-clay, plumbago or coke-dust is mixed; but neither of these increases its durability, though diminishing its liability to break on account of sudden changes of heat. This well-mixed mass is firmly *pounded in an iron mould, with a moveable cone for the interior.* The crucible which is thus formed is air-dried and slightly burned before it is employed in the melting of cast steel. For this purpose a crucible 5 inches wide at the top, and 16 or 18 inches in height, is generally employed. Every precaution must be taken to prevent it from cracking; for, in such a case, its contents are generally lost.

The air-furnace for the fusion of the steel is similar in construction to those used by brass-founders: it is 2 feet deep and 12 inches square. The flue at the top is covered by a cast-iron trap-door. The top of the furnace coincides with the plane of the floor of the laboratory. Under the floor of the latter is an arch, into which the grates of the furnace may be emptied: this arch supplies the furnace with air, and in it the ashes accumulate. The crucible is placed on a support composed of two thicknesses of fire-brick, and its top is covered with a lid. In many cases, pounded glass and blast-furnace cinders are laid on the top of the steel, as well to prevent the access of air as the oxidation of the carbon; but, if the lid fits well, this precaution is unnecessary: besides, these materials generally tend to glaze, and, as a consequence, to crack the crucible. In large factories, ten or twenty furnaces may be put in one row, each furnace having its own chimney. In England, the fuel employed is coke; but anthracite is far superior to coke for this purpose. The more compact the fuel, the better will be the result. In feeding the furnace with coal, great caution must be observed; for a sudden charge of cold fuel is apt to crack the crucible. For this reason, square are preferable to round furnaces. The heat of the furnace must be conducted in such a manner that the melting shall commence from below, and not from the top. This is another reason why the form just described is preferable to any other

All these advantages are increased by the employment of blast, which, of course, is essential where anthracite is used.

The time required to melt steel depends partly upon the draught of the furnace, partly upon the quality of the crude steel, and partly on the quality of the article designed to be manufactured. From one to three hours is generally required for a crucible containing 50 lbs. of metal. The stronger the steel, the greater the length of time consumed. The mass must become perfectly liquid, no matter how long a time is required to produce this result. The liquid steel is then poured into previously heated cast-iron moulds, and cast in the shape of square or octagonal bars, 2 inches thick. Before casting, the steel in the crucible is stirred with a hot iron rod, after which a strong heat is applied for a few minutes. After casting, the top of the steel in the mould is covered with clay, to prevent its blistering, and to prevent the access of air.

The cast rods are exposed to a cherry-red heat, and put, when almost black, to the hammer. The rapid succession of strokes heats the steel, and, if it is very hard, often in too high a degree. Each hammer requires a tilter and two boys. In this case, as in that of blistered or German steel, hammering and heating need the utmost attention. The quality of the steel depends upon the quickness with which the work is performed. The rods are heated in heating stoves, constructed like sheet-iron ovens.

Steeler, the foremost or aftermost plank in a strake, which is dropped short of the stern or sternpost of a vessel

Steelyard, in statics, a kind of balance having arms of unequal length, in which the weight is moved along the longer arm, and becomes in effect heavier in proportion as it is removed from the fulcrum or support. It was formerly named the *Statera Romana*, or Roman balance.

Steeple, a spire or lantern; the superstructure attached to the tower of a church

Steering-wheel, a wheel to which the tiller-rope is attached, for the convenience of steering a ship

Steeving, in navigation, denotes the elevation which a ship's cathead or bowsprit is above the stem, or the angle which either makes with the horizon

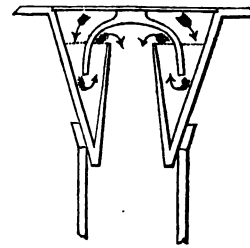
Stem, the foremost piece of timber in a ship

Stem, in mining, a day's work

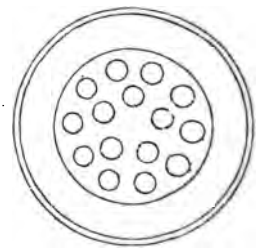
Stemples, in mining, wooden pieces by which to go up and down the mine, instead of steps

Stemson, a piece wrought on the aft-part of the apron, continued as high as the middle deck or upper deck in small ships, the lower end lapping on or scarfing into the keelson

Stench-trap, a contrivance for the prevention of the escape of effluvia from sinks and drains. These traps



Section of Stench-trap.



Plan of Ditto.

are on the same principle as a gasometer: a cup inverted in water stops the escape of gas. (See the preceding plan and section of a trap in common use.) The circular plan shows how the fluid is drained off through small holes. The arrows in the section show the course which the fluid takes in its way into the pipe leading into the drain. It will be evident, from an inspection of the section, that the inverted cup will be immersed in the fluid as high as the dotted lines. If, from neglect, the space intended for fluid only should be suffered to become filled with solid matter, the fluid will cease to run in the direction indicated by the arrows, and the utility of the traps will be destroyed: they should, therefore, be kept constantly clear from solid matter.

Some persons, not understanding the principle on which the trap is constructed, remove the inverted cup when the water can no longer flow through it, and then leave it off. The consequence is, that, there being nothing to impede the gas from the drains from rising and flowing into the dwelling-houses, the houses very frequently become filled with noxious air.

Step, in ship-building, a large piece of timber into which the heel of a mast are fixed

Steps for the masts are large pieces fitted across the keelson, into which the heel of the mast is fixed. The holes for the mast to step into should be cut in proportion to the steps, so as to leave sufficient wood on each side of the hole to answer in strength to the tenon left at the heel of the mast; and if that should be rather too little, the hole may be cut more thwartships to answer the deficiency the fore and aft way. There are likewise large pieces called steps of the cupstands; and steps on the top-side, for the convenience of getting on board.

Stereobate, or *Stylobate*, a base; the lower part or basement of a building or column

Stereography, the art of drawing the forms of solids on a plane

Stereometry, in geometry, the mensuration of solids

Stern, the aft-part of a ship

Stern-frame, the frame of timber that is composed of the stern-post, transoms, and fashion-pieces

Stern-post, the straight piece of timber at the aftermost part of a ship, and to which both sides of the ship unite: the lower end is tenoned into the keel. It is generally worked with the but-end upwards, being most suitable to the conversion of the timber; but in some ships which trade to a hot climate it has been preferred to work the but-end downwards, because in large ships it requires a piece of such growth whose juices towards the but are nearly exhausted, and therefore it is supposed to last longer under water; whereas, by the heat of the weather, when the but is worked upwards, it decays with dry-rot for want of moisture.

Stern-sheets, in navigation, that part of a boat which is contained between the stern and the hindermost seat of the rowers

Stiff, in navigation, denotes the quality by which a ship is enabled to carry a sufficient quantity of sail without danger of oversetting

Still-house. Rules are given for building these houses: the first caution is to lay the floor aslope, not flat, where any wet work is to be performed. It should be also well flagged with broad stones, so that no wet be detained in the crevices, but all may run off and be let out at the drains made at the bottom and sides. Stills for wines should be placed abreast on that side of the still-house to which the floor has its current. Fronting the stills, and adjoining to the back of the wall, should be a stage for holding the fermenting-backs; so that these

being placed at a proper height, may empty themselves by means of a cock and a canal into the stills, which are thus charged with very little trouble. Near this set of fermenting-backs should be placed a pump or two, that they may readily supply them with water by means of a trunk or canal leading to each back. Under the pavement, adjoining to the stills, should be a kind of cellar, whereon to lodge the receivers, each of which should be furnished with its pump to raise the low wines into the still for rectification; and through this cellar the refuse wash or still-bottoms should be discharged, by means of a hole or other contrivances.

Stilobatum, in architecture, denotes the body of the pedestal of any column. (See *Stereobate*.)

Stone - Coal Furnaces — Anthracite Furnaces (American). In Eastern Pennsylvania more than sixty blast-furnaces, supplied by anthracite, are most generally in operation. These produce on an average from seventy-five to eighty tons of iron per week. This immense number of furnaces, supplied by stone coal alone, was the result of ten years' industry; and the perfection to which they have been brought is a security that nothing can check their use, or prevent their extension.

Anthracite furnaces resemble, to a greater or less degree, coke and charcoal furnaces. They are seldom so high as coke furnaces, and their horizontal dimensions are usually greater than those of charcoal furnaces. The following are the dimensions of several of the furnaces recently erected in Eastern Pennsylvania. One belonging to Mr. Ecket, at Reading, is 37½ feet in height; the top or throat 6 feet in diameter; height of hearth, 5 feet; tuyères, 22 inches above its bottom: the hearth is 5 feet square at the base, and 6 feet at the top; the boshes are inclined 67½°, or at the rate of 6 inches to the foot, and measure 14 feet at their largest diameter. At the point where the slope of the boshes joins the lining, a perpendicular cylindrical space, 5 feet in height, commences, and from this point the general taper to the throat is continued in a straight line. The hearth, as well as the boshes, is built of coarse sandstone, but the latter are covered with a lining of fire-brick, 9 inches thick. The in-wall consists of two linings, and the interior is the lining which covers the boshes; outside of this is a space 4 inches wide, filled with coarse sand, and this is protected by a rough lining of slate, 2 feet thick. The rough walls of the stack are not heavy, but they are well secured by binders.

Two furnaces erected at the Crane Works, near Allentown, may be considered as the greatest improvement. The stack is 35 feet high, 40 feet square at the base, and at the top 33 feet. This furnace is therefore but slightly tapered, and requires heavy stone-work. It generates steam from the trunnel-head gas flame. At most anthracite furnaces, this is done by putting the boilers on the top of the furnace. The hearth is 5 feet high, 4 feet square at the bottom, and 6 feet at the top; the inclination of the boshes is 75°, and the cylindrical part of the in-wall above the boshes is 8 feet high and 12 feet in diameter. From the cylindrical part up to the top, which is 6 feet in width, the in-wall runs in a straight line.

A furnace erected by Messrs. Reeves and Co., at Phœnixville, is 34 feet in height: the hearth is 6 feet high, 4 feet 3 inches square at the bottom, and 5 feet 3 inches at the top: the boshes taper 68°, or at the rate of rather less than 6 inches to the foot: they measure 13 feet at the widest part. Great care is taken that the lining and the boshes form a gradual curve,

that sticking and scaffolding in the boshes may be obviated. The top of this furnace is 8 feet square. There is no doubt that the form and construction of these anthracite furnaces have been carried, within the short space of a few years, to so high a state of perfection as to leave but little room for future improvements. Their shape is worthy of imitation, particularly by Western manufacturers; for coal adapted to all of these furnaces is abundant in the Western States of America.

Most of these furnaces generate the steam for the motive power of the blast, as well as the heat for the hot-blast apparatus at the top of the furnace. In this way expense is not only saved, but an uniform generation of steam and heating of air are produced. The cost of erecting such a furnace cannot be readily estimated, as it must depend greatly upon locality, material, wages, and individual tastes; but it may be laid down as a general rule, that a stone-coal furnace costs less than a coke furnace, and that, in most cases, a good charcoal stack can be altered so as to serve for stone coal.

In the Western States, many charcoal furnaces are in operation, and there is no limit to their extension, so far as raw material, wood, and ore are concerned. One circumstance, however, will necessitate the introduction of stone-coal furnaces in the West, namely, the price of charcoal iron. Some localities can successfully compete against stone-coal iron; but those which, besides enjoying that advantage, are situated near navigable streams or canals, are very few in number. It is said that the average cost of producing charcoal pig at Pittsburgh is 20 dollars; some furnaces produce it at a cost of 15 dollars: in as many cases, however, 25 dollars is paid for iron. *The market-price at Pittsburgh varies from 25 to 30 dollars*, according to quality; and at this price little profit is left to the owners of the furnaces. How far the stone-coal furnaces are in advance of this will be shown by the following statement of the average result of three years' smelting. This statement was furnished by Mr. Reeves, of Philadelphia:

Amount of material consumed to produce one ton of iron at anthracite furnace No. 1, *at Phœnixville.*

	Tons.
Iron ore	2·59
Anthracite coal . .	1·83
Lime	1·14

Amount consumed at furnace No. 2, *at the same place.*

	Tons.
Iron ore	2·65
Anthracite coal . .	1·89
Lime	1·15

These furnaces smelt brown hematite, hydrated oxide of iron. The wages for producing one ton of anthracite iron, including all incidental expenses, amount to 2 dollars 50 cents, to which is to be added the interest on capital employed.

Anthracite furnaces require wider tops than coke furnaces, while the latter require far wider tops than charcoal furnaces. This width of the top may be considered the most essential improvement on the blast-furnace which is supplied by anthracite coal. The height of the stack in anthracite is much less than in coke furnaces, and somewhat lower than in charcoal furnaces. Anthracite furnaces vary from 30 to 35 feet in height; charcoal furnaces, from 30 to 40 feet in height; and coke furnaces, from 40 to 60 feet. The width of the trunnel-head varies, in the United States, considerably. In Pennsylvania, Ohio, Kentucky, and Tennessee, the width of furnaces at the boshes is 9 and often 10 feet, and at the top from 18 to 20 inches; or in the proportion of 30 square feet at the boshes to 1 square foot at the top. The

Cold Spring furnace measures at the boshes 9 feet, and at the top 32 inches: here the proportion is 11 feet at the boshes to 1 foot at the top.

The dimensions of charcoal furnaces in Europe which smelt refractory ores, are generally in the proportion of 5 feet at the boshes to 1 foot at the throat; frequently in the proportion of 4 to 1. In coke furnaces, the proportion of the horizontal section of the boshes to that of the top is seldom less than 4 to 1, though sometimes even 2·5 to 1. In anthracite furnaces, the diameter of the throat is 6 feet, and that of the boshes 12 feet; that is, in the proportion of 1 to 4. But sometimes the boshes measure 13 and the tops 8 feet square: in this case, the proportion is as 2 to 1. Taking into consideration the small height of the stack, and the strong blast which is applied, it is found that this arrangement in anthracite furnaces is, in an economical point of view, very favourable; for, instead of retarding, it facilitates the vent of the gases. Narrow tops answer where loamy ore and soft coal are used; but, in such cases, to obtain favourable results, weak blast and high stacks should be employed. But these conditions can be observed only where coal and labour are cheap. If any doubt exists concerning the proper dimensions of a furnace, the best course is to commence with a comparatively low stack, wide throat, and with as high a pressure in the blast as the fuel will possibly bear.

Stone ochre. The true stone ochres are found in balls or globular masses of various sizes, in the solid bodies of stones lying near the surface of rocks among the quarries in Gloucestershire or elsewhere. These balls are of a smooth compact texture, in general, free from grit, and of a powdery fracture; they vary exceedingly in colour, from yellow to brown, murrey, and gray, but do not differ in other respects from the Oxfordshire ochre, and may be safely used in oil or water in the several modes of painting, and for browns and dull reds in enamel.

Stools, pieces of plank fastened to a ship's side to receive the bolting of the gallery

Stopper-bolts, large ring-bolts drove in the deck of a ship before the main-hatch, for the use of the stoppers

Stopping, in mining, cutting down mineral ground with a pick

Stories, in architecture. Palladio directs that the height of the story immediately above the principal floor be a sixth part less than that below; and if there be an attic or third story, it should be nine-twelfths of the height of that immediately under it.

Stoup, an old English term for the holy-water basin placed at the entrance to a church: it is applied also to a vessel for carrying about and distributing holy water amongst a Roman Catholic congregation

Strake, in ship-building, one range of planks fore and aft

Strap, in carpentry, an iron plate placed across the junction of two or more timbers, either branched out or straight, as may be found requisite, and each branch bolted or keyed, with one or more bolts or keys, through each of the timbers, for the purpose of securing them together

Strata, in geology, extensive layers of any mineral substance, such as rocks, &c. Secondary strata are nearly all comprised under the heads of sandstone, limestone, and shale.

Streamers, in mining, the persons who work in search of stream-tin

Stream-tin, in mineralogy, particles or masses of tin found beneath the surface of alluvial ground, and separated from the earthy matter by passing a stream of water over it: hence the name.

Strength and stress of materials. The works of Barlow and Tredgold on

tain the most useful information on these subjects. Barlow shows that there are four distinct strains to which every hard body may be exposed; and which are,—1st, a body may be pulled or torn asunder by a stretching force, applied in the direction of its fibres, as in the case of ropes, stretchers, king-posts, tie-beams, &c.; 2ndly, it may be broken across by a transverse strain, or by a force acting either perpendicularly or obliquely to its length, as in the case of levers, joists, &c.; 3rdly, it may be crushed by a force acting in the direction of its length, as in the case of pillars, posts, and truss-beams; 4thly, it may be twisted or wrenched by a force acting in a circular direction, as in the case of the axle of a wheel.

Stretching-course, in brick-work and in masonry, a row or course in which the bricks or stones are placed with their longest faces exposed to view. The bricks or stones thus laid are called stretchers; and those disposed with the ends outwards are called headers.

Strigæ, in ancient architecture, what are now called flutings

String, in mining, a small vein

String, the strake under the gunwale within side, generally worked the same thickness as the sheer-strake, and scarfed in the same manner: the string and sheer-strake are bolted through a ship's side

String-course, a narrow, horizontal, and slightly projecting course of brick-work or masonry in the wall of a building

Stucco, in architecture, a composition of white marble pulverized and mixed with plaster or lime, but the ingredients vary; it is employed commonly for facing exterior and interior works; it is also sometimes used for floors

Stück or *Wulf's oven*, a furnace for the reduction of iron, at one time common in Europe, now little employed. The interior of this furnace has the form of two cones united at their bases: it is usually from 10 to 16 feet high, 24 inches wide at bottom and top, and 5 feet at the centre. There are generally two tuyères, both on the same side. The opening called the breast is closed after the furnace is heated, after which, charcoal and ore are thrown in, and the blast introduced. As soon as the ore passes the tuyère, iron is deposited at the bottom of the hearth: when this amounts to a ton, the blast is stopped, the breast wall removed, and the metal lifted out in a solid mass, or *stück*, *wulf*, as it is called by the Germans.

Studding-sails, in navigation, certain light sails extended beyond the skirts of the principal sails in moderate steady breezes; named also 'goose-wings'

Studies. In painting, these signify works which a painter undertakes, to acquire a practical knowledge of his art and facility of execution. The term is also applied to the parts taken separately, which the artist afterwards transfers to the picture.

Stuffing-boxes, in a locomotive engine, those with recesses for admitting some soft material, such as white spun-yarn, to render steam-tight any rod working through this stuffing or packing. The piston-rods, slide-valve rods, regulator-rods, and pump-plunger, all work through stuffing-boxes of this description.

Stull, timber placed in the backs of bevels and covered with boards, or small piles, to support rubbish

Sturt, in mining: when a tributer takes a pitch at a high tribute, and cuts a course of ore, he sometimes gets two, three, or five hundred pounds in two months: this great profit is called 'a sturt'

Styles of early Architecture in England. The several examples, usually denominated Gothic, are as follows: 1. The Anglo-Roman, which existed about 300 years. 2. The Anglo-Saxon, about 450 years. 3.

Anglo-Norman (*which continued in use even on the introduction of the Pointed style*), about 85 years. 4. Early Pointed (*termed also the Lancet style and Early English*), about 140 years. 5. The Pointed style (*called by some pure Gothic*), about 110 years. 6. The Florid Pointed (*termed also the Perpendicular*), about 140 years. 7. The Tudor, Elizabethan, and Stuart, (the latter of which is called by Mr. Britton 'the Revival,') about 120 years.

Stylobate, the substructure of a Greek temple below the columns, sometimes formed of three steps, which were continued round the peristyle; and sometimes of walls raised to a considerable height, in which case it was approached by a flight of steps at one end

Subtangent, in geometry, in any curve, is the line which determines the intersection of the tangent in the axis prolonged

Subtense, in geometry, the chord of an arch; that which is extended under any thing

Sucker, in mechanics, the embolus or piston of a pump. In pneumatics, a round piece of leather, which, laid wet on a stone and drawn up in the middle, leaves a vacuum within, which, by the pressure of the atmosphere, makes it adhere.

Sulphate of copper (blue vitriol), in chemistry, metallic salt, a compound of sulphuric acid and copper

Sulphate of iron (copperas or green vitriol), in chemistry, a metallic salt, a compound of sulphuric acid and iron

Sulphate of lead, an exceedingly white precipitate from any solution of lead by sulphuric acid, much resembling the *blanc d'argent*, and which has, when well prepared, quite neutral, and thoroughly edulcorated or washed, most of the properties of the best white-leads, but is rather inferior in body and permanence

Sulphate of lime (gypsum, &c.), in mineralogy, a compound of sulphuric acid and lime

Sulphate of zinc (white vitriol), in chemistry, metallic salt, a compound of sulphuric acid and zinc

Sulphur, a simple combustible substance found native in a loose powder, either detached or in veins. It is met with in the neighbourhood of volcanoes, where it is deposited as a crust on stones contiguous to them. It can be prepared by exposing iron pyrites to heat, when part of the sulphur is driven off in vapour, and may be collected in water: when vaporized, it condenses in small crystalline particles, called flowers of sulphur. It is inflammable, burning slow with a pale blue flame. Sulphur is found in connection with silver, copper, lead, antimony, and iron. Sulphur occurs, in nature, crystallized in acute octahedrons with rhombic bases. It is principally brought to this country from Sicily.

Sulphuret of hydrogen. This gas, commonly known as sulphuretted hydrogen, is invaluable as a re-agent in separating one class of metals from another, is precipitated by it in acid solutions from another gas, and only acted upon by it in alkaline solutions.

Sulphurets of iron.—Iron has a very great affinity for sulphur: there are five definite compounds of these substances. It is very difficult to separate iron from sulphur by heat alone. Of the five different compositions, two only deserve attention,—the white and the yellow sulphurets.

White sulphuret of iron (*white pyrites*) abounds in coal-beds, and in the accompanying strata of clay; also in regular veins, along with ores of lead, copper, and iron, in the transition rocks. Before the flame of the blow-pipe, it becomes red; upon charcoal, the sulphur is evaporated, and oxide of iron remains. It is very liable to decomposition: it is preferable to the yellow kind in the manufacture of copperas, and is, in coal mines, the

most dangerous of any, as it often decomposes so quickly as to kindle the coal-slack. Its composition is, in 100 parts,

45·07 iron
53·35 sulphur
0·58 manganese

99·00 white pyrites.

Yellow sulphuret of iron, yellow pyrites. — This variety becomes red before the blow-pipe; and in the reducing flame it melts into a globule, which continues red-hot for a short time, and possesses, after cooling, a crystalline appearance. In nitric acid it is slowly soluble, with the precipitation of sulphur, but in no other acid. It is composed of

47·30 iron
52·70 sulphur

100·00 yellow pyrites.

Yellow pyrites is almost identical with the white pyrites, and the latter appears to be only different in containing more foreign matter: both are widely diffused among the ores of iron, and are found in massive nodules, crystals, and veins, in the coal beds, clay-slate, graywacke, greenstone, limestone, and in beds of primitive slate. It is the main material which is used for manufacturing copperas, alum, oil of vitriol, Spanish brown, and sulphur.

Summer, a horizontal beam or girder

Sump, in mining, a pit sunk in the engine-shaft below the lowest workings

Sump-shaft, the engine-shaft

Supercilium, the transverse antepagment of a doorway. The word is also used to denote the small fillets or bands above and below the scotia of the Ionic base.

Superficies, in geometry, the surface of any body or figure, considered as possessing two dimensions, or extension in length and breadth, *but destitute of thickness*: in mensuration, *it is estimated as area*

Supporters, in heraldry, figures standing on a scroll and placed by the side of the escutcheon, such as the lion and the unicorn in the British, and the angels in the French arms

Supporters, in ship-building, the knee-pieces under the cathead

Surmarks, in ship-building, the stations of the ribbands and harpings which are marked on the timbers

Surveying is the art of applying the principles of geometry and trigonometry to the measurement of land. The principal operations are laying down or *driving* base lines and triangles on either side of the base. In large surveys it is desirable to lay down these triangles by measuring each angle with an instrument called the *theodolite*, by which the accuracy of the measurement of the sides may be checked. The theodolite is also available in fixing the true position of points, the distances between which are immeasurable, owing to the intervention of buildings, rivers, or other obstacles. Rectangular or irregular areas of land are similarly reduced to triangles, and their exact position referred to a base line. In driving lines over land, three long poles are requisite: these are ranged in the direction of the intended line at the greatest distance at which they can be seen, either with the naked eye or with the assistance of a telescope, and driven firmly into the ground. Intermediate stakes are then fixed, by which the line is marked out. In proceeding onward to extend the line included between the front and back pole, the latter only is removed, and carried before the front pole to the greatest practicable distance, and being ranged by the two remaining poles, is there driven. Thus the middle pole becomes the back one, and is in like manner removed to the front, and there ranged and fixed: and in this manner, by successively removing the back pole, and conveying it to

the front, the line is extended as far as necessary. These poles should be as light as possible, consistent with strength, and shod with iron points, to facilitate driving. On the top of each pole a flag or disc is fixed, to render them conspicuous from a long distance. Distances are measured with a chain formed of wire links, the length of the chain being 66 feet, and formed with 100 links, each link measuring 7·92 inches. The end of each chain is marked by driving a wire pin or arrow into the ground, by counting which the number of chains measured is ascertained. The base line being thus driven and measured, it is recorded in a book, and all intersections of fences, &c. marked, and their relative distances on the base are entered. A distant point on either side of the base is then determined, and a pole erected upon it, and the distance of this point from two fixed points upon the base measured with the chain, and duly recorded. By this means, a triangle is completed, and afterwards correctly filled in with all intervening fences, &c.; and by repeated processes of this kind the survey is extended to any required distance on each side of the base. If the triangles first laid down are of great extent, they should be determined, and the position of their angles ascertained with the theodolite. This instrument consists of a pair of horizontal circular plates, the upper of which is called the vernier plate, turning freely on a centre upon the lower plate, the edge of which is chamfered off, and accurately graduated with degrees and subdivisions. By these plates and their adjusting screws, &c., horizontal angles are measured, the sight of the surveyor being aided by a powerful telescope on the upper part of the instrument, and a microscope to read off the graduations upon the vernier. An upper frame which carries the telescope also supports a vertical arc or semi-circle, which is likewise graduated, and with the aid of another microscope the elevation of any high object, as a tower, &c. (observed through the telescope) may be correctly read off. This part of the apparatus thus enables vertical angles to be measured, and by the application of trigonometry heights or distances may be thus easily determined without the actual measurement of all the lines in each vertical triangle.

Suspension, in mechanics, as in a balance, are those points in the axis or beam where the weights are applied, or from which they are suspended

Suspension. Bridges of suspension are of several kinds and of various dimensions, consisting of several iron chains, not formed of single links, like cables, but of whole bars of iron jointed at their ends, passing over a tower, being the access to the bridge on each side of the river, while their extreme ends are firmly attached to large and ponderous stones that are sunk a great depth into the ground on each side of the stream. These masses of masonry are named *abutments*. The chains hang in parallel festoons over the river, between the supporting towers, and carry a number of vertical bars of iron that are attached to and hang down from them for the purpose of suspending beams of wood or iron hanging horizontally in the direction of, or obliquely to, the stream, and serving as joists to support a strong planked platform or roadway that extends across the river: frequently these roadways are paved, or at least gravelled and ballasted over for horses, carriages, and pedestrians. Extraordinary examples exist of this species of bridge in our own country, viz. that at Bangor, crossing the Menai Strait, by Telford,—that at Hammersmith, by Tierney Clark,—Hungerford, by Brunel; but the most extraor-

structure is the stupendous of Tierney Clark, uniting with Buda, in Hungary. Mr. e has constructed several r bridges of suspension, ac- g to his arrangement, both land and Scotland, and Lieut.- oodwyn also, in India, with nodifications of Dredge's ad- ents. Suspension bridges have onstructed also with wire as erial at Fribourg, in Switzer- and at other places.

or *Tiller-Sweep*, a circular fitted to support the foremost f the tiller, or handle of a , much improved by convey- e tiller-rope round it, and g it always tight

mechanics, something fixed ther body so as to turn round a kind of ring made to turn in a staple or other ring.

illery, a very small cannon, carries a shot of about half- d.

e-tree, a species of the ficus, tree, common to Europe; lled the great maple, and in nd and the north of England ane-tree: its mean size is 32 gh. It is a very clean wood, ling the plane-tree, but much . The colour of the young re is silky white, and of the ownish white; the wood of ddle age is the intermediate ur, and the strongest. It is furniture, piano-fortes, and and for the superior kinds bridge ware. Sycamore may into very good screws, and for presses, dairy utensils,

y, in sculpture, &c., adaption to each other; proportion; ay; agreement of one part nother

meter, a barometrical instru- n which the atmospheric e is indicated by the ascent lumn of oil in a short glass *ainst the elastic pressure of sed volume of hydrogen* gas. Its indications require correction for the changes produced by temperature on the gas. The instrument is more compact, but also more complex, than the mercurial barometer.

Synagogue, a word which primarily signified an assembly, but, like the word *church*, came at length to be applied to places in which any assemblies, especially those for the worship of God, met, or were convened. Jewish synagogues were not only used for the purposes of divine worship, but also for courts of judicature. The present ordinary meaning of the term synagogue is a Jewish church.

Syphering, in ship-building, lapping one edge of a plank over the edge of another for bulk-heads, making the edges of the planks and the sides of the bulk-head plain surfaces

Syphon, a bent tube, having one leg shorter than the other. It acts from the pressure of the atmosphere being removed from the surface of a fluid, which enables it to rise above its common level, and is used for the purpose of emptying liquors from casks, &c.

Syphon. The date of the first application of the principle by which water or other fluids may be drawn from one level to another by the exhaustion of the air contained in the limb communicating with the lower level, appears to be very remote. The Egyptians certainly used it for the transvasing of wine: but the first important application of this principle to useful or general practice was in the aqueduct which conducted the springs of Mount Pila to Lyons: the date of this aqueduct is about 40 years after the commencement of the Christian era. Upon the total length of the aqueduct, which with its branches was 15 old French posting leagues, there were three large syphons to carry the water from the upper sides of the same number of valleys

contains also the Mishna, and the Gemara of Rabbi Asa, of Babylon, about the year 400: this is much more valued than the other, on account of its great clearness or perspicuity, and also for its extensiveness, though it abounds in fables and ridiculous stories, which the Jews entertain with such eagerness, that they compare the Bible to water, the Mishna to wine, and the Gemara to hippocrass, affirming that Moses revealed those traditions and explications to Aaron, to his sons, and the elders, and that he received them from God.

Talus, in architecture, the inclination or slope of a work, as the outside of a wall, where its thickness is diminished by degrees as it rises in height

Tamping, in mining, the material, usually soft stone, placed upon the gunpowder to confine its force, which would otherwise pass up the hole; also the process of placing the material

Tamping-iron, a tool used for beating down the earthy substance in the charge used for blasting

Tangent, in geometry, a right line perpendicularly raised on the extremity of a radius, which touches a circle so that it would never cut it, although infinitely produced, or, in other words, it would never come within its circumference

Tank, that part of the tender of a locomotive engine which contains the water: tanks vary in size, according to the power of the engine to which they are attached, and are from about 500 to 1600 gallons in capacity

Tap, in mechanics, a hardened steel screw with a square head, so that it may be turned by a wrench: it is grooved from end to end, and is also slightly tapered: it is used for cutting an internal screw, as that of a nut, &c.

Tap-wrench, the handle for turning a wrench

Taper, a gradual diminution in the size of a body, so as to form or cone

Taper-chain bridge, a sus bridge invented by Mr. (See *Dredge's Suspension B*

Tapestry, or *Arras*, descri 'hangings,' enriched the superior apartments from ve times: the most ancient t now existing is preserved church of Bayeux, in Nor and exhibits an entire serie circumstances attending the Conqueror's descent in E The arras was loosely hung jecting frames, by tenter- against the walls, which were times not even plastered, e the whole surface from the f the ceiling, and was, like mo furniture, removeable from o dence of its owner to anothe most costly materials we ployed in the fabrication best sort of hangings. The ment of Henry VIII. at whither he was accompanied Boulogne by Francis I. in 152 hung with cloth of gold, a with precious stones and pe the old inventories, cloth o and cloth of silver, and emb frequently occur, as well a of silk and gold mixed, called kin. The walls of the gallery Hou House, the residence of C Wolsey, which was seized k king, were "hanged with c gold, and tissue of divers m and cloth of silver likewise o sides, and rich cloths of hand divers colours."

Tappet-motion, the appara working the steam-valve of a nish steam engine, consisti levers connected to the moved at proper intervals b pets or projecting pieces fixed rod connected to the beam

Tartan, a small coasting vessel Mediterranean, with one bowsprit, and a lateen sail

Taunt, a sea term signifying or tall, as the mast of a

is a native of the moun-
ıarts of the Malabar coast,
Ceylon, &c. It grows
straight, and lofty. The
ight and porous, and easily
but it is nevertheless
ınd durable. It is soon
, and, being oily, does not
on, and shrinks but little
Its colour is light brown,
esteemed a most valuable
ı India for ship-building
e-carpentry. It has many
. In twenty-five years the
ins the size of 2 feet dia-
nd is considered service-
ber, but it requires 100
arrive at maturity.
roofing tile: roofing tiles
ıde by the Greeks like
baked clay
ɔr *Atlantes*, statues of men
l in columns or pilasters
al architecture
a machine adapted for
cating intelligence rapidly
iderable distance by means
ıs signals previously ar-

ı large optical instrument
ving the celestial bodies,
several new phenomena
:n discovered, and great
ıents made in astronomy:
rly grinding and placing
s or glasses in a tube or
ırious lengths, objects at
istance are brought nearer
, and much more distinctly
ı by the natural eye: there
ɔus kinds of telescopes,
: called by distinct names
e. The temperature of
unding atmosphere exer-
ıowerful influence in the
on or decomposition of
ic bodies exposed to it.
ıile a high temperature
he decay of animal and
matter, it is completely
ıt or near the freezing-
ater. Hence, by artificial
ese substances may be
or a length of time. A
citizen of the United States has thus accomplished the means of preserving meats, fruits, &c. A large apartment is built under the ground, the sides of which are lined with a double wall containing saw-dust: over the ceiling is a room filled with ice, which, gradually melting, filters through the saw-dust, and keeps the temperature of the underground apartment always at 34° Fahr., or two degrees above the freezing-point. In this apartment, lemons, oranges, apples, strawberries, flowers, &c., are preserved with complete freshness for any length of time that may be required.

Temperature of different Thermometers. A thermometer is an instrument for measuring the temperature of bodies, or the degree of intensity of their sensible heat. In Europe there are three different kinds of thermometers: 1. Fahrenheit's, which is used chiefly in Great Britain, Holland, and North America, the freezing-point on which is at 32°, and the boiling-point 212°. 2. Reaumur's, which was that chiefly used in France before the revolution, and now generally used in Spain, and in some other continental states: the freezing-point, or zero, is 0°, and the boiling-point 80°. 3. The Celsius, or Centigrade thermometer, now almost universally used throughout France, and in the northern and middle kingdoms of Europe: the zero or freezing-point is 0°, and boiling-point 100°. Hence, to reduce degrees of temperature of the centigrade thermometer, and of that of Reaumur, to degrees of Fahrenheit's scale, and conversely,— Rule I. Multiply the centigrade degrees by 9, and divide the product by 5; or multiply the degrees of Reaumur by 9, and divide the product by 4; then add 32 to the quotient in either case, and the sum is the degrees of temperature on Fahrenheit's scale. Rule II. From the number of degrees on Fahren-

heit's scale subtract 32, multiply the remainder by 5 for centigrade degrees, or by 5 for those of Reaumur's scale, and the product in either case, being divided by 9, will give the temperature required.

In all inquiries into the effects of heat, it is necessary to attend to the following rules respecting the application of the term *Temperature:*

1stly. If a body subject to no pressure, or to a constant pressure, have at two different times the same bulk, it is said on both occasions to have the same temperature.

2ndly. Two bodies are said to have the same temperature, if, being kept in contact, the temperature of either remains unaltered by the action of the other.

3rdly. When bodies of different temperatures are in contact, the temperature of the hotter body decreases, and that of the colder increases, till they become equal.

4thly. If the bodies be equal in mass or in weight, and of the same substance, the increase of temperature in one will be equal to its decrease in the other.

Hence it will be seen that differences of temperature are measurable and comparable with each other, quite independently of any change of bulk; that is, without using the latter as a measure of temperature, but only as a test by which change of temperature is detected.

In this way it has been discovered that the same increment (not equal increments, as from 40° to 50°, and from 50° to 60°) of temperature causes all masses of the same substance to expand in the same ratio to their whole former bulk; but this is by no means the case with different substances, as is obvious by looking at a common thermometer, an instrument for measuring changes in the bulk of a mass of liquid contained in a glass vessel, of such a form that changes, very small compared with the whole bulk of the liquid, may cause its surface to rise and fall through a considerable space. But this could not be done if the glass and the measuring scale, in undergoing the same changes of temperature as the liquid, experienced also the same change of bulk; for, if such were the case, the liquid surface would always remain opposite the same degree on the scale. The value of this simple instrument, therefore, depends on the fact, that liquids are more expansible than solids.

But it will further be seen that the ratio of the change of bulk to the whole bulk is different for every different substance, when the change of temperature is the same in all. It is necessary, however, to guard against a very common error respecting the relation between temperatures and the numbers by which they are represented; namely, the degrees of the thermometer.

Although the differences of temperatures are known and comparable quantities, yet their ratios are not so: they can be compared by addition and subtraction, but not by multiplication or division. We cannot say, "This temperature is so many times that," because we do not know the real zero of temperature; that is, we do not know what is the smallest bulk into which a given body is capable of being condensed by cold. We cannot, therefore, say, "This body exceeds its minimum bulk by twice as much as that body exceeds its minimum bulk;" or, in other words, "This body is twice as hot as that;" for although the temperature of one body may be 80° and that of another 40°, these numbers are only reckoned from an arbitrary zero or starting-point, adopted because the real zero is unknown. But although we cannot say that A has twice the temperature of B, we can

say that the temperature of A exceeds that of B by twice as much as the temperature of C exceeds that of D.

The first question, then, regarding the relation of expansion to temperation, is—"Do equal differences of temperature cause the bulk of a body to vary by equal differences?" This question had to be settled before it could be known whether the common thermometer (the scale of which is divided into equal parts) measured differences of temperature correctly. For this purpose, Dr. Brooke Taylor heated two equal weights of water, one to 200° and the other to 100°, and, on mingling them together, he found them to indicate exactly 150°; thereby showing that equal differences of temperature cause equal differences in the expansion of mercury; or rather in the excess of its expansion over that of glass, which is clearly all that the thermometer can measure. More accurate experiments, however, have shown that this rule does not exactly apply to any solid or liquid, but only to gases. When equal masses of the same liquid, at different temperatures, are mixed, their combined bulk becomes a very little diminished. Liquids, therefore, instead of expanding by equal increments of space for equal increments of temperature, expand faster as the temperature increases equably; and it appears that the correctness of the mercurial thermometer observed by Dr. Brooke Taylor was the result of a fortunate coincidence, by which the expansion of the glass, which is very small compared with that of the mercury, exactly compensated the increasing rate of the latter. This, however, would not be the case with thermometers constructed with other liquids, for their rates of expansion increase more rapidly than that of mercury. Hence spirit thermometers cannot be depended on for temperatures above the atmospheric range (or above 100°).

Tempering, in metallurgy, the preparing of steel or iron, so as to render them more compact, hard, and firm, or the reverse, more soft and pliant

Tempering of steel. Nearly every kind of steel requires a particular degree of heat to impart to it the greatest hardness of which it is susceptible. If heated, and suddenly cooled below that degree, it becomes as soft as iron: if heated beyond that degree, it becomes very hard, though brittle; and its brittleness is an indication of the degree of its heat, when cooled off. These are the reasons why, in hardening steel, it is generally overheated, and then tempered. To hit the exact heat required is a matter of extreme delicacy.

The hardening of steel may be perfectly understood by studying its nature. In endeavouring to arrive at the temperature best adapted to a particular case—a case, for instance, in which a strange kind of steel has to be dealt with—a practical test, namely, drawing the bar into a tapered point or chisel, is applied. This wedge-shaped chisel will, of course, be more warm towards the point than at the thick part; and it is evident that this part will, when cooled in the same cold medium, be harder than the thick part. By breaking, and continuing to break off, the point, the difference of grain will show the different temperatures which have been applied. The finest and closest grained is considered the best. In hardening such steel, it is heated with a due relation to the degree of the test heat. Though this manipulation is very imperfect, careful and intelligent workmen are generally quite successful in arriving at a knowledge of what degree is favourable. The degree of hardness

depends, in some measure, upon the heat of the steel, but mainly upon the difference between the heat of the steel and that of the water or medium in which it is cooled. The coldest water will make the hardest steel. Mercury is better adapted to harden steel than water; so is water, acidulated with any kind of acid, or containing any kind of salt in solution.

The process of hardening is performed with due relation to the quality of the steel and the purposes for which it is designed. In most instances, the hardening is effected in water or brine. Saw-blades are thus hardened, after being heated in melted lead; and sabres are heated in a choked fire of charcoal, and then swung rapidly through the air. Mint stamps are hardened in oil or metallic compositions. The common method of procedure in hardening is this: The steel is overheated, cooled in cold water, and then annealed or tempered by being so far re-heated that oil and tallow will burn on its surface; or the surface is ground and polished, and the steel re-heated until it assumes a certain colour. The gradations of colour consecutively follow: a light straw yellow, violet, blue, and finally gray or black, when the steel again becomes as soft as though it had never been hardened.

Templa, certain timbers introduced in the roofs of temples; they were placed upon the canterii, or principal rafters, extending the whole length of the temple from one fastigium to the other, corresponding in situation and use with the common purlins

Temple, a building set apart for the services of religious worship, especially the Jewish, and those which were dedicated to the heathen deities: the name is not unfrequently applied to Christian sanctuaries, for example, the Temple church, London. The first Jewish temple, built by Solomon, was erected at vast expense; the gold and silver only, which was provided for the purpose, amounting, it is said, to an almost incredible sum. It was built much in the same form as the Tabernacle, only every way of larger dimensions. It was surrounded, except the front or east end, with three stories of chambers, each 5 cubits square, which reached to half the height of the temple, and the front was graced with a magnificent portico, which rose to the height of 120 cubits, so that the shape of the whole was not unlike some churches which have a lofty tower in the front and a low aisle running along each side of the building. This temple was plundered by Nebuchadnezzar, King of Babylon, and the building itself destroyed, according to Josephus, after it had stood between 400 and 500 years. The second temple, erected after the Jews' return from Babylon, stood for 500 years, when Herod rebuilt it in a style of great magnificence. Tacitus, the Roman historian, calls it a temple of immense opulence. This magnificent temple was at length destroyed by the Romans in the same month and on the same day of the month as Solomon's temple was destroyed by the Babylonians. Of the temples of classic history, the most celebrated are those of Greece, consisting of the Parthenon, built under Pericles, the Erechtheum, and others noticed in Stuart's 'Antiquities,' and in the works of the Dilettanti Society, of Cockerell, Donaldson, &c.: of Rome, the chief temples were, the Capitol, the Pantheon (built by Agrippa), the temple of Apollo, the temple of Janus, and others interestingly described by Degodetz, and also by Taylor and Cresy.

Templet, a gauge cut out of a thin piece of metal to the form of the work to be executed.

Templum (Latin), a temple. Temples appear to have existed in Greece from the earliest times; they were separated from the profane land around them, and the entrances were much decorated as architecture advanced.

Tenacity, that quality of bodies by which they resist tension or tearing asunder

Tender, the carriage which is attached to a locomotive engine, and contains the supply of water and coke

Tenon, in carpentry, the square end of a piece of wood or metal diminished by one-third of its thickness, to be received into a hole in another piece, called the mortise, for the jointing or fastening of the two together

Tension, a force pulling or stretching a body, as a rod. Animals sustain and move themselves by the tension of their muscles and nerves. A chord, or string, gives an acuter or deeper sound as it is in a greater or less degree of tension, that is, more or less stretched or tightened.

Tension-rod, an iron rod applied to strengthen timber or metal framing, roofs, &c., by its tensile resistance

Term, a piece of carved work placed under each end of the taffrail of a ship, at the side timbers of the stern, and extended down as low as the foot-rail of the balcony

Terra cotta, in the arts, baked earth, bricks, tiles, &c.

Terra di Sienna, or *Raw Sienna Earth*, a ferruginous native pigment, which appears to be an iron ore, and which may be considered as a crude natural yellow lake, firm in substance, of a glossy fracture, and very absorbent. It is in many respects a valuable pigment, of rather an impure yellow colour, but has more body and transparency than the ochres; and being little liable to change by the action of either light, time, or impure air, it may be safely used, according to its powers, either in oil or water, and in all the modes of practice. By burning, it becomes deeper orange, and more transparent and drying.

Terre-verte, an ochre of a bluish-green colour; in substance moderately hard, and smooth in texture. It is variously a bluish or gray coaly clay, combined with yellow oxide of iron, or yellow ochre. Although not a bright, it is a very durable pigment, being unaffected by strong light and impure air, and combining with other colours without injury. It has not much body, is semi-transparent, and dries well in oil. There are varieties of this pigment; but the green earths which have copper for their colouring matter are, though generally of brighter colours, inferior in their other qualities, and are not true terre-vertes.

Tesselated, in the arts, variegated by squares; exemplified in the beautiful pavements of the ancients

Tessera, small cubical pieces of brick, stone, or composition, forming part of an ancient Roman mosaic or tesselated pavement

Testaceous, consisting of shells; made of baked earth, or of tiles or bricks

Tetragon, a quadrangle, or a figure having four angles

Tetrahedron, in geometry, one of the five regular bodies of solids comprehended under four equilateral and equal triangles. It may be conceived as a triangular pyramid of four equal faces.

Tetrants, the four equal parts into which the area of a circle is divided by two diameters drawn at right angles to each other

Tetrastyle, a portico, &c. consisting of four columns. A cavædium was called tetrastyle when the beams of the compluvium were supported by columns placed over against the four angles of a court.

Thatch, straw or reeds employed for covering the roofs of buildings; particularly used for cottages

Thaughts or *Thwarts*, in navigation, the benches or seats in a boat

Theatres, edifices of various but principally of large dimensions, for dramatic exhibitions

Theatrum, a theatre. The Athenians, before the time of Æschylus, had only a wooden scaffolding on which their dramas were performed. It was merely erected for the time of the Dionysiac festival, and was afterwards pulled down.

Theodolite, in surveying, a mathematical instrument for measuring heights and distances. (See Heather's work on Instruments.)

Theory, a doctrine which terminates in the sole speculation or consideration of its object, without any view to the practice or application of it. To be learned is an art, and the theory is sufficient; to be master of it, both the theory and practice are requisite. Machines often promise very well in theory, but fail in practice. A remarkable circumstance may be instanced of a gentleman of British North America selling his estate and leaving his home to give practical effect to a theory he had, as he considered, beautifully worked out in figures, for an important improvement in steam machinery. His theory, however, wholly failed on its first application in practice.

Theory, mathematical, the algebraic elucidation of the principles of any physical system, where assumptions are made, in the absence of positive data: the calculated results are expressed in formulæ, which are easily convertible into arithmetical rules. Among others, the 'Theory of the Steam Engine,' by the Count de Pambour, has been found to be most useful for practice; and the following is an explanation of his mathematical investigation, designed for persons not familiar with the algebraic signs, and intended to render clear and easy the use of the formulæ contained in the abovementioned work, and which may be said to have reference to all mathematical works.

Among persons engaged in the construction or working of steam engines, there is a great number to whom the algebraic terms are little familiar, and who usually give up the reading of a book as soon as they perceive that it steps beyond the simple notions of arithmetic. When it is intended to make a work profitable to those persons, the usual practice is to annex to each of the definitive formulæ an explanation, in full words, of the arithmetical operations which it represents.

The want of such explanation may be very advantageously supplied, by giving the signification of every sign employed in the formulæ, by explaining what are the arithmetical operations represented by those signs. With the help of a very few rules on this subject, persons will find that the reading of the formulæ is quite as easy in algebraic signs as if they were written in words; since, after all, it is but an abridged way of expressing the same things, and moreover, the operations to be performed, in order to attain the result, are much more clear, and more easy for the mind to seize. Again, a perfect acquaintance with the signification of the signs in common use can require but a few hours of attention, and when once a person shall have made himself master of them, he will be capable of reading the formulæ of all works.

A, B, ... a, b, ... l, m, n, ... α, β, ... &c. The letters are an abridged manner of writing the numbers which those letters represent. Thus, when the stroke of the piston has been measured, and found, for instance, to be 17½ inches, it would be inconvenient to write in all the formulæ the number 17½. But if the length of stroke, whatever it might be, has been represented by a letter, as l, for instance, then, every time the letter l occurs, there needs only to be collect that it represents the

ber 17½, and performing with that number the operations indicated in the formulæ, relative to the letter l, the result sought will be attained.

= .... This sign signifies *equal to;* it expresses that a quantity sought is equal to the number resulting from certain operations performed on other quantities known. Thus, for instance, if we find the expression

$$V = 60\,v,$$

this will signify that the quantity V is equal to 60 times the quantity v. Consequently, if we know besides that the letter v represents the number 100, it will follow that the unknown quantity V will have for its value 60 times 100, or 6000.

+ .... This sign signifies *plus* (more). Placed between two letters or two numbers, it indicates that they are to be added together. If, for instance, there be in a formula an expression of the form

$$1 + \delta,$$

it means that to the number 1 must be added the number δ. If, then, we know besides that the letter δ represents the number ·14, it follows that the expression $1 + \delta$ will have for its value

$$1 + \delta = 1 + \cdot 14 = 1\cdot 14.$$

− .... This sign indicates *minus* (less). Thus, when an expression occurs of the form

$$P - f - 2118,$$

the expression amounts to saying that, from the number P the numbers f and 2118 are to be successively subtracted. If, then, we know that the letter P represents the number 9360, and that the letter f represents the number 144, the expression will have for its value

$$P - f - 2118 = 9360 - 144 - 2118 = 7098.$$

× .... This sign expresses *multiplied by*. Thus the expression

$$a \times v$$

indicates that the two numbers represented by the letters a and v are to be multiplied one by the other; and the product of that multiplication will be the quantity expressed here by $a \times v$. This multiplication to be performed is equally expressed by a point between the two letters, or by writing the two letters simply together without any sign interposed; so that the expressions

$$a \times v \ldots, \quad a \,.\, v \ldots, \quad a\,v,$$

amount to the same, all three expressing the result of the multiplication of the numbers represented by a and v. If, for instance, an expression occur like the following,

$$a\,r\,v,$$

and it be known that the letter a expresses the number 1·57, the letter r the number 2640·96, and the letter v the number 300, the expression $a\ r\ v$ will have the value

$$a\,r\,v = 1\cdot 57 \times 2640\cdot 96 \times 300 = 1243800.$$

÷ .... This sign denotes *divided by*. Thus the expression

$$\frac{S}{a}$$

expresses S divided by a, or the quotient resulting from the division of the number expressed by S, by the number expressed by a.

For instance, if we have S = ·67 and a = 1·57, it is plain that the term $\frac{S}{a}$ will have for its value

$$\frac{S}{a} = \frac{\cdot 67}{1\cdot 57} = \cdot 4268.$$

A fraction may have its numerator or its denominator composed

of several numbers, on which divers operations are indicated. In that case, those operations must first be performed, so as to reduce the numerator and the denominator to single numbers, before performing the division of the one by the other, as has just been said.

If, for example, we have the fraction

$$\frac{10000}{1{\cdot}492 + {\cdot}002415\ \mathrm{P}},$$

and know besides that the letter P represents the number 9360; we must first perform the multiplication of the number 9360 by the number ·002415, and then add to the product the number 1·492. The result will be the number 24·0964, which will therefore represent the denominator of the fraction. The fraction may then be written under the form

$$\frac{10000}{24{\cdot}0964},$$

and consequently it is reduced to the simple indication of the quotient of two numbers, as in the preceding case.

If two fractions occur, separated by the sign of addition, or that of subtraction, or that of multiplication, the meaning is that, after having sought separately the quotient indicated by each of those fractions, they are either to be added together, or one deducted from the other, or one multiplied by the other. Thus, the expression

$$\frac{\mathrm{S}}{a} \cdot \frac{10000}{1{\cdot}492 + {\cdot}002415\ \mathrm{P}}$$

signifies that, after having sought the quotient indicated by each of the two fractions, the first of these quotients is to be multiplied by the second. Supposing the letters to be of the same numerical value as in the preceding cases, the product of the two fractions would here be the definitive number 176.

It would be the same were to find one fraction by another. Each of them be first reduced to a single by finding the quotient they sent, and then the one o quotients divided by the oth

( ) or [ ] or { }....

theses indicate that the d quantities contained betwee are to be reduced to a singl ber before performing the operations indicated in the fo

Thus, for instance, if we a formula the expression

$$(1 + \delta)\, v,$$

this means, that it is the exp $(1 + \delta)$ entire, which is multiplied by v. The sum t $1 + \delta$ is first to be formed afterwards multiplied by the ber v; whereas, had we only

$$1 + \delta\, v,$$

this would mean that the p δv is first to be formed, and wards the number 1 added t

There may occur several theses comprised one withi other, but their significati always the same. The expr

$$\cdot 002415\,[\,(1 + \delta)\, r + f\,]$$

denotes that the sum of 1 to be formed first, this to b tiplied by r, and the product to the quantity f, which giv number represented by the parenthesis; and finally, th number is to be multipli ·002415.

Lastly, when there occu the formulæ a letter with a figure or exponent above it the same thing as writing letter as many times successi there are units in the figure ponent.

For instance, the expressio

$$v^2$$

is equivalent to the e

$v \times v$, or v written twice; that is to say, it is the product of v by itself. If then v were known to be equal to 300, the quantity represented by v^2 would be

$$v^2 = 300 \times 300 = 90000.$$

These short explanations are all that is necessary, in order to read and perfectly understand all practical formulæ. Replacing each of the signs that are met with in a formula, by the periphrasis which the sign represents, you read the formula such as it ought to be expressed; and effecting the arithmetical operations indicated by those signs, you attain the result sought. A formula is, then, nothing more than an abridged manner of writing the series of operations to be performed, in order to arrive at the result which we want to obtain.

We will subjoin to this explanation some examples, taken from the practical formulæ of high-pressure engines.

I. Suppose we have the formula

$$v = \frac{S}{a} \cdot \frac{10000}{6{\cdot}6075 + {\cdot}002415\,[(1+\delta)\,r + f]},$$

which is intended to determine the unknown value of v; and let it be supposed that we know, besides, that the other letters comprised in this formula have the following value:

$$\begin{aligned} S &= {\cdot}67 \\ a &= 1{\cdot}57 \\ \delta &= {\cdot}14 \\ r &= 2641 \\ f &= 144. \end{aligned}$$

First form the sum $(1+\delta)$, indicated in the inner parenthesis, which will be

$$1 + \delta = 1{\cdot}14.$$

Then multiply this number by r, or 2641, and the result will be

$$(1+\delta)\,r = 1{\cdot}14 \times 2641 = 3010.$$

Add to this f, or 144, and the sum will consequently be the quantity indicated by the outer parenthesis, viz.

$$[(1+\delta)\,r + f] = 3154.$$

Now multiply this sum by the number ·002415, and the product will evidently be

$${\cdot}002415\,[(1+\delta)\,r + f] = {\cdot}002415 \times 3154 = 7{\cdot}6170.$$

Add to this last result the number 6·6075, and you obtain

$$6{\cdot}6075 + {\cdot}002415\,[(1+\delta)\,r + f] = 6{\cdot}6075 + 7{\cdot}6170 = 14{\cdot}2245.$$

This is then the denominator of the fraction which forms the second member of the formula. Performing the division of the number 10000 by the number just obtained, the quotient will be

$$\frac{10000}{6{\cdot}6075 + {\cdot}002415\,[(1+\delta)\,r + f]} = \frac{10000}{14{\cdot}2245} = 703{\cdot}04.$$

On the other hand, dividing S by a, or the number ·67 by the number 1·57, you have the value of the fraction $\frac{S}{a}$, viz.

$$\frac{S}{a} = \frac{{\cdot}67}{1{\cdot}57} = {\cdot}4268.$$

Finally, then, multiplying this latter quotient by that obtained immediately above, you have definitively

$$v = \frac{S}{a} \cdot \frac{10000}{6{\cdot}6075 + {\cdot}002415[(1+\delta)r + f]} = {\cdot}4268 \times 703{\cdot}04 = 300.$$

Thus it is clear that by effecting successively the series of calculations indicated by the few signs which are explained, and proceeding gradually from the most simple terms to the more compounded ones, we arrive without difficulty at the definitive result.

We will give some other examples of these calculations; but, instead of effecting the operations, we will merely express in words

the signification of the formula, which amounts to the same.

II. Suppose we have the formula

$$a\,r = 4140750\,\frac{S}{(1+\delta)v} - \frac{a}{1+\delta}\,(2736+f);$$

this signifies that the required value of $a\,r$ will be obtained by performing the following arithmetical operations:

Add 1 to the number represented by the letter δ, and multiply the sum by the number v.

Then divide the number S by the product thus obtained; multiply the quotient of this division by the number 4140750; and write apart this first partial result, which represents the first term of the formula.

Add again to unity the number δ, and by that sum divide the number a.

Similarly add to the number 2736 the number f, and multiply the sum by the last found quotient; and set apart this partial result, which represents the second term of the formula.

Finally, from the first partial result subtract the second, and the difference will be the quantity $a\,r$ sought.

Performing these different operations with the values of S, a, δ, r and f, given above, and supposing the case wherein the letter v has the value $v = 300$, you find that the quantity $a\,r$ will have for its definitive value

$$a\,r = 4146.$$

III. If we have the formula

$$S = \frac{a\,v}{10000}\left\{6{\cdot}6075 + {\cdot}002415\,[(1+\delta)\,r+f]\right\};$$

it will amount to the following arithmetical explanation:

To the number 1 add the number δ, and multiply the sum by the number r.

To this product add the f, and multiply the result by the number ·002415.

To the latter product number 6·6075, and keep a partial result, which expr one number, what proce all the operations comprise great parenthesis.

Then multiply the num the number v, and divide duct by the number 1000 will give you another parti expressing the portion of mula situated beyond the thesis.

Finally, multiply the for tial result by the latter, definitive product will be quired value of S.

For the values above at to the different letters cont the formula, the result of culation will give S = ·67.

IV. If we have the form

$$v' = \frac{S}{a}\cdot\frac{10000}{1{\cdot}492 + {\cdot}00241}$$

it will be paraphrased as fo

Multiply the number ·00 the number P, and add to duct the number 1·492; di number 10000 by the su obtained, and write the apart.

Then divide the numbe the number a, which will second quotient.

Finally, multiply the form tient by the latter, and the ing product will be the value of v'.

With the values alread cated for the letters, and, over, for P = 9360, the r the preceding formula wi $v' = 176$.

V. In fine, as a last exam will suppose the formula

$$a\,r' = \frac{a}{1+\delta}\,(P - f - 2$$

It plainly will signify as fo
From the number P d

the number f, and again from the remainder deduct the number 2118.

Then to the number 1 add the number 3, and divide the number a by the sum thus obtained.

Finally, multiply this quotient by the difference before obtained, and the definitive product thus formed will be the required value of $a\,r'$.

The operations thus indicated would, for the case wherein the letters should have the values already given above, produce for the required value of $a\,r'$ the quantity 9777.

Thus we see how easy it is to replace all the formulæ by their expressions in words; and, consequently, the sight of algebraic formulæ ought in nowise to intimidate persons unfamiliar with algebra.

Theotheca, *Monstrance*, or *Remonstrance*, sacrament-house in the Roman Catholic Church (the pix), the receptacle of the consecrated host, made generally of the most costly materials, and, in some cases, of expensive and beautiful design. Two magnificent examples are given in the 'Divers Works of Early Masters.' The sacrament-house in the church of St. Lawrence at Nuremburg, date 1510, is 64 feet in height; and another, in the church of St. George at Limbourg, is upwards of 30 feet high.

Thermometer, an instrument used for measuring the degrees of heat. (See *Temperature of different Thermometers.*)

Thesaurus (Greek), a treasure-house. That buildings of this description were required, especially by kings and states, in the earliest period of civilization, is self-evident; and tradition points to subterranean buildings in Greece, of unknown antiquity and of peculiar formation, as having been erected during the heroic period, for the purpose of *preserving precious metals, arms, and other property.*

Thole, a term used in building: the scutcheon or knot in the midst of a timber vault; also a place in temples where donaries (gifts) were hung up

Tholobate, a cupola, and a base: that part of a building on which a cupola is placed

Tholus, an appellation given to all buildings of a circular form. Vitruvius uses it to signify the roof of a circular building.

Thowl, a piece of timber by which oars are kept in their places in rowing

Throat, in ship-building, the hollow part of knee-timbers.

Throttle-valve, a valve in the steam-pipe of an engine, for regulating the supply of steam to the cylinder. In land engines it is generally connected to a governor.

Thuríble, a censer used in some of the services of the Roman Catholic Church, made usually of metal in the form of a vase

Thurl, a long adit in a coal-pit

Thymele, in antiquity, a sort of altar, surrounded with steps, placed in front of the Greek stage or orchestra

Thyrorea, the doors of a Greek temple or house

Thyroreum, a passage in the houses of the Greeks, at one end of which was the entrance from abroad, and at the other the doorway leading to the peristyle

Tiara, an ornament for the head, anciently used by the Persians

Ticketings, the weekly sales of ores. The adventurers or their agents meet together at noon, and whilst sitting round a table, each buyer gives in his ticket, offering a certain sum per ton for so many tons of ore. The tickets are then read aloud by the chairman, and the persons present note the prices offered, the lots or different samples being sold to the highest bidder.

Tide, the natural fluctuation of the water of the sea and some rivers, whereby it increases and diminishes its quantity at particular times and places, the first being called the

tide of flood, the last the tide of ebb: when the tide or flow of water runs against the wind, it is called a windward tide, in which case the sea breaks most, and runs highest

Tide-gauge. The merit of this invention is due to Mr. Meik, the engineer of Sunderland Harbour, whose attention had been for some time directed to the necessity of having conspicuous tide-gauges erected at all harbours and docks. Intrusted with the management of a tidal harbour with an intricate and narrow channel, and where frequently from 150 to 200 sail of vessels entered or quitted during a single tide, he perceived that the number of vessels that could safely depart on their outward voyage depended not only on the extent of each tide, but also on the knowledge of those in charge as to the rate of its flow, by which alone they would be enabled to form a correct judgment as to the sufficiency of water to enable the vessels to proceed to sea.

It was evidently essential that any tide-gauge for this purpose should be rendered intelligible to seamen of all grades, and so situated as to be seen from all vessels in time to allow the course of those outward bound to be checked, should there not be sufficient depth of water to enable them to pass over the bar; or should the vessel be inward bound, and the depth indicated by the gauge proved insufficient, she might be brought up, or put off again to sea; also if the vessel was at anchor in the roadstead, the captain on board should be able to know, from prominent characters, the earliest time at which he could take the harbour.

The first port provided with a regular set of signals for this purpose was that of Leith. The signals used there are very complete, and, with the assistance of a careful man to work the system according to the rise of the tide, are of essential benefit to the shipping. But few seamen pay sufficient attention to matters of this kind to carry in their memory the exact depth of water corresponding to the signals shown; and before the book is consulted, the vessel may be driven on the shore, or stranded on the bar.

The signals at Leith, although perfect of their kind, are used only during the day; while it is evident that night is the time when they are most required by seamen, to inform them of the state of the tide. By day they generally have some imperfect mode of arriving at the depth of water, by observing when the tide reaches certain points on shore, or covers some known rocks at sea; but at night they cannot guess at the tidal flow even by such inaccurate means, and consequently the gauge-marks or figures should have the property of being clearly distinguished at night as well as by day, otherwise little advantage will be gained, nor will the loss of life be materially lessened.

From these considerations, and for the purpose of exhibiting the advantages to be derived from their adoption at the different ports, a self-acting tidal gauge, combining the above-mentioned properties, as far as relates to outward-bound ships, has been erected at Sunderland Harbour, by Mr. Meik, in conjunction with Mr. Watson, of Newcastle.

The construction of the gauge is as follows: A well, carefully boxed in, and of similar depth to the water on the bar, is sunk below the building which contains the apparatus. Within this well, in an interior pipe or trunk, and rising and falling with the tide, works a float suspended by a copper wire cord, which is carried over a spiral cone fixed in an upper story of the building. By the simple arrangement of a wheel and pinion at the oppo-

site end of the axle to which the cone is fixed, a web of wire gauze works on two rollers fixed at the upper and lower ends of the web. The lower roller is regulated by the movement of this wheel and pinion; the upper one by a balance-weight attached to a copper wire cord, which also passes over another spiral cone, having at the extremity of its axle a second wheel and pinion similar to the first. As the float rises and falls with the tide, the wheels and pinions connected with the cones, over which the cords of the float and balance-weight respectively pass, move the rollers on which the gauze web travels. On this web are painted in large figures the various depths from high to low water, and as the web works, two fixed pointers indicate the number of feet and half-feet on the bar at any hour of the tide.

The web and the figures on it can be made of any size, and to travel 4, 6, 8, 10, or any other proportion to 1 of the float, by regulating the size of the wheels and pinions. By day the figures on the web are shown white on a black ground; by night they appear distinctly lighted up, the ground still remaining dark. A white transparent varnish is used for the figures, and an opaque black for the ground. The illumination by night is so steady and powerful, that the figures, if made large enough, and the apparatus fixed at a sufficient elevation, are visible at a considerable distance at sea, and thus afford vessels the means of knowing the exact depth of water at the mouth of any harbour before entering it. This simple piece of mechanism is applicable to all places where the want of a correct and conspicuous gauge has been felt, not only in harbours and docks, but at railway stations, for signals and such like purposes. The apparatus used occupies so little space, that it can all be contained and worked in a column or pillar, without any other building.

In the same building is erected, for the Commissioners of the River Weir, a self-registering tide-gauge, to which it is also intended to fix a barometer. The working of this self-registering gauge, which has for some time been in use at a few other ports, is as follows: A pencil is fixed in a rack, which registers the variations of the tide, the time of each change being also marked; and immediately under which is a cylinder. On this is fastened a sheet of paper, properly ruled for the purpose, and of sufficient size to receive the variations of the tide, traced by the pencil, for fourteen days. The rack containing the pencil is connected with a wheel, over which a copper wire cord passes, having attached to it a float, which works in a well of similar construction to that already described as used for the new tide-gauge. This float and cord move, by the action of the tide, the rack and the pencil in it, and trace the diagram on the paper below. A dial on one side of the rack is worked by the same machinery, and points out as a clock the hours and minutes of the day, and the number of feet from high to low water.

A time-piece, furnished with a strong minute-hand, gives the revolving movement to the cylinder on which the paper is rolled, and serves to mark the time of the variations of the tide. The float and wheel, in fact, are the means of showing the depths of water; the time-piece, the exact hour and minute of each change of tide.

Tie-beam, a beam which acts as a string or tie, to hold together two things which have a tendency to spread apart

Tie-rod, a wrought-iron bar or rod for bracing together the frames of steam engines, roofs, &c.

Tierce, a vessel containing forty-two gallons, or the third part of a pipe: in the Romish Liturgy it is one of the canonical hours for prayers, viz. eight in the winter, and ten in the summer, at night: at cards it is a sequence, or three following cards of one sort: in heraldry it is the division of a shield into three equal parts

Ties, in navigation, the ropes by which the yards hang; in mechanics, tension-rods

Tigna, the principal timbers of a roof extending across ancient temples, in contradistinction to the trabes, which were timbers placed upon the columns or walls in the same direction with them. The tigna correspond to our tie-beams.

Tiles, baked clay in thin plates of different shapes, used to cover roofs. Tiles curiously and richly ornamented were formerly used in the early Christian churches for pavements.

Tiller, a piece of timber fitted into the head of a rudder, to which it forms a handle

Tilt-hammer. The most simple machine by which iron is forged is the German forge-hammer, often called the tilt-hammer. This machine, often of a fanciful form, is very extensively employed. The leading principle sought in its construction is solidity; and various forms have been invented to give permanency to the structure, which is mainly endangered by the action and re-action of the strokes. The cast-iron tilt-hammer varies in weight, according to the purposes for which it is designed, from 50 to 400 pounds. For drawing small iron and nail rods, a hammer of the former size is sufficiently heavy; but for forging blooms of from 60 to 100 pounds in weight, a hammer weighing 300 or 400 pounds is employed. Such a hammer should be cast from the strongest gray iron, and secured by wooden wedges to the helve.

Timber-man, in mining, the man employed in placing supports of timber in the mine

Timbers, in ship-building, the ribs which branch outwards from the keel in a vertical direction

Timbers in the head, in ship-building, pieces with one end bearing on the upper cheeks, and the other extended to the main rail of the head

Timbers of ermine, a term in armoury or blazon; the rows or ranks of ermine in noblemen's capes

Tin. This very useful metal is found in small round lumps, in the beds of some rivers near the mines, the principal of which are in Cornwall, but it is generally in nature as an oxide, though occasionally as a sulphate, and associated with many other metals. Tin is a silvery white metal, with a very slight shade of yellow: the purest is the grain-tin, which is prepared from what is found in the river beds, and known as stream-tin, and is judged by its splitting when a mass is heated till it is brittle and allowed to fall from a height. It is very malleable and soft: it dissolves in hydrochloric acid, evolving hydrogen gas: nitric acid converts it into a hydrated binoxide.

Tin, oxide of. When tin is digested in strong nitric acid, a whitish powder is deposited, which, after being washed, and subsequently fused and pulverized, is known in the arts under the term *putty-powder*, and is used for polishing glass, stones, &c.

Tin white resembles zinc white in many respects, but dries badly, and has even less body and colour in oil, though superior to it in water. It is the basis of the best white in enamel painting. There are various other metallic whites of great body and beauty, such as are those of bismuth, antimony, quicksilver, and arsenic; but none of them are of any value or reputation in painting, on account of their great dispo-

sition to change of colour, both by light and foul air, in water and oil.

Tincture, a staining or dyeing; also a term in heraldry, signifying a variable hue of arms

Tinsel, a kind of cloth composed of silk and silver, glistening like stars or sparks of fire

Tire, in mechanics, the strong iron hoop that binds the circumference of a wheel

Tires, of locomotive engines, the outside hoops round the wheels, generally with a flange to keep and guide them on the rails. Stephenson's patent engine and eight-wheeled engines are usually made without flanges on the tires of the driving wheels. Some tires are steeled on the part subjected to most wear, which renders them more durable.

Titanate of iron (*Titaniferous iron, Iron sand,*) is an oxide of iron and titanic acid, and belongs to the class of the magnetic oxides. It is attracted by the magnet, is of a deep black colour, metallic lustre, very hard, and perfectly opaque; melts into a black slag by a high temperature. It is generally found near volcanoes or volcanic rocks, but seldom in quantities sufficient to justify the erection of iron-works; nevertheless the quality is mostly good, and the volcanic regions around the lakes of America may present, in the course of time, encouraging prospects.

Titanium. This metal is found occasionally in the slag of smelting-furnaces, in small cubical crystals of a copper colour: it exists in anatase, and several varieties of titanate of iron, but combined with oxygen.

Ton, a weight which varies in different districts: the common ton is 20 cwts. of 112 lbs., or 2240 lbs.; in Cornwall the miner's ton is 21 cwts. of 112 lbs., or 2352 lbs.

Tontine, a term derived from the name *of the inventor, Lorenzo* Tonti, a *native of Naples*, who originated the scheme so called, first adopted in 1653, in France. The subscribers were divided into ten classes, according to their ages, or were allowed to appoint nominees, who were so divided; and a proportionate annuity being assigned to each class, those who lived the longest had the benefit of their survivorship, by the whole annuity being divided amongst the diminished number. Some remarkable cases have occurred in England: a tontine of a recent date consisted of a less number than ten members, all of whom, with the exception of one, died within a very few years from the commencement, leaving this survivor in the receipt of an enormous sum of money annually, derivable from the profits of the undertaking, which are unvarying

Tools, instruments employed in the manual arts for facilitating mechanical operations, namely, hammers, punches, chisels, axes, adzes, planes, saws, drills, files, &c., by means of percussion, penetration, separation, and abrasion of the substances operated upon; for all of which operations various motions are required to be given either to the tool or to the work. In handicraft work the tool receives motion, but in self-acting or automatic tools, motion may be given to either. In the case of the turning lathe, the tool remains fixed, and the object moves. In that of the planing machine, the tool may remain fixed, or be made to move according to the duty required to be performed. In almost all other machines, such as the slotting, the key-grooving, the punching, the drilling, the nut-cutting, the teeth of wheels cutting, the boring, the screw-cutting machines, the tools receive motion. In the screw, bolt, and nut machines the tool is either moveable or fixed. The use of handicraft tools is coeval with the earliest periods of antiquity, and the recent researches c

modern travellers have proved the ancients to have been acquainted with almost all the tools now in use. The potter's wheel, the axe, the chisel, the saw, &c., attest the perfection to which the mechanical arts were carried by the Greeks and Romans; and subsequently in the arts of turning exhibited by the Dondi family, in the construction of their clocks and of machines for spinning silk, in the middle of the 13th century, in Italy, and afterwards by Bessoni, De la Hire, De la Condamine, Grand Jean, Plumier, and Morin. The three plates of Bessoni show the different modes of turning and cutting screws of all sorts of fancy-work. De la Hire shows how all sorts of polygons may be made by the lathe, and Condamine shows how a lathe may be made to turn all sorts of irregular figures by means of tracers moved over the surface of models and sculptures, medals, &c.; and this is perhaps the first idea of the machine called the *Tour à Portrait*.

The work of Plumier enters most extensively into the art of turning, for he shows the construction of the lathe and its different parts, the art of making, hardening, tempering, and sharpening tools, the different kinds of motions which may be given to the lathe by means of wheels, eccentrics, and models, and the different inventions relative to works of art which have been performed by the lathe, among which may be mentioned the moveable or slide rest. In the common rest which supports the tool, the idea of fixing the tool and pushing it in the direction of the parallel bed of the lathe, so as to cause the tool to traverse the work parallel to it, must have been obvious; and as this could have been easily effected by means of the screw and handle, it required little ingenuity to carry out the idea to its fullest extent, by constructing a rest to allow of the slide traversing the horizontal or vertical plane in any direction. The machine described by Plumier is neither more nor less than the slide-rest and planing machine combined: it consists of two parallel bars of wood or iron connected together at both extremities by bolts or keys of sufficient width to admit of the article required to be planed: a moveable frame being placed between the two bars, and motion being given to it by a long cylindrical thread, is capable of giving motion to any tool which may be put into the sliding frame, and consequently either causing the screw, by means of a handle at each end of it, to push or draw the point or cutting edge of the tool either way. If also motion be given to the tool by means of guides upwards or downwards, it is evident that any kind of reticulated form can be given to the work, as in the machine described by Plumier, which was intended for ornamenting the handles of knives, and which is called by Plumier, *Machine à Manche de Couteau d'Angleterre*, from its having been an English invention. The *Machine à Canneler*, described by Bergeron, a mode of grooving columns, is probably derived from the same source, from its resemblance to the English machine. The origin of the planing machine, in more recent times, is said to have arisen from the grooving or fluting of the drawing rollers used in cotton machines, shortly after the introduction of Arkwright's inventions. The patent of Sir Samuel Bentham in 1793, for various new methods for working wood, metal, and other materials, certainly contemplates the working of tools similarly to the tools employed in the planing machine, as it comprehends giving all sorts of motion to tools: and the patent of Joseph Bramah, taken out in 1802, was "for machinery for producing

straight, parallel, and smooth surfaces and other materials requiring truth, in a manner more expeditious and perfect than can be performed by the use of axes, screws, planes, and other cutting instruments used by hand in the usual way."

Billingsby, of Birkenshaw, took out a patent in 1802, for boring cylinders in a vertical position, although horizontal machines had their advantages. The boring of large cylinders by horizontal machines had long been practised by Smeaton, Wilkinson, Walker, Darby, and Boulton and Watt, and at Butterley and other great iron-works; but it was many years subsequently that the vertical boring machines came into use.

As respects the introduction of the first planing machines which have been used during the present century, opinions are at variance. Messrs. Fox, of Derby, the eminent tool-makers, state that the first machine employed for this purpose was constructed by Mr. Fox, senior, in the year 1821, for the purpose of planing the wrought and cast iron bars used in the lace machines: the machine was capable of planing an article 10 feet 6 inches in length, 22 inches in width, and 12 inches in depth: others give the credit of the invention to Manchester, and G. Rennie, Esq., puts in a claim for constructing a planing machine with a moveable bed, urged by an endless screw and rack, and furnished with a revolving tool, so early as 1820, having several years previously employed the principle for grooving and planing parallel bars.

Mr. Bramah, in 1811, employed the revolving cutter to plate iron. Mr. Clement states that he made a planing machine, for planing the sides of weaving looms and the triangular bars of lathes, previously to 1820. He afterwards constructed a beautiful machine for planing large and small work with the greatest accuracy. The bed moved on rollers, and the tools cut both ways. The beautiful work executed by this tool, for Mr. Babbage's calculating machine, evinces the perfection of its performance. It is thus by the aid of automatic tools that the greatest precision and identity of parts in machinery is produced; and it is probable that, ere long, the chisel, the file, and the grindstone will be banished from the factory, and that nicety of parts and uniformity and silence of action, blended with the science of construction, will eventually supersede the expensive and imperfect construction of the handicraft syster

Toon wood is of a reddish br colour, rather coarse-grained, used all over India for fu and cabinet-work

Top and *But*, in ship-buildi. general method of workin English plank (except in the top-side) to make good work and conversion, which is by disposing of the top end of every plank within 6 feet of the but-end of the plank above or below it, leaving all the planks to work as broad as possible, so that every other seam is fair

Top-timbers, in ship-building, the uppermost timbers: the first general tier of timbers that reaches the top of the side are, or should be, called top-timbers; those which scarf on the heads of the upper futtock are called short timbers

Torricellian tube, in pneumatics, a glass tube named after the inventor, open at one end and hermetically sealed at the other

Torricellian vacuum. This is produced by filling a tube with mercury, and allowing it to descend to such a height as to be counterbalanced by the pressure of the atmosphere, as in the barometer.

Torsion is that force with which a thread or wire returns to a state of rest after it has been twisted by being turned round on its axis

Torsion-electrometer, an apparatus for measuring the intensity of electricity

Torus, the convex member of the Tuscan and Ionic bases. In the attic base there is both an upper and lower torus.

Tossing, *Tozing*, or *Terloobing*, a process consisting in suspending ores by violent agitation in water: their subsidence being accelerated by packing, the lighter and worthless matter remains uppermost

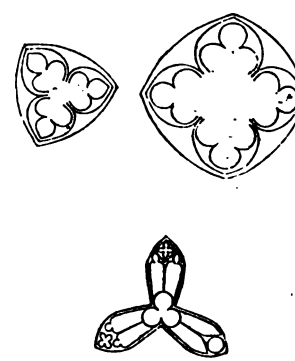
Tower, an ancient elongated vertical building, variously formed and constructed in different countries

Town Hall, Mansion House; in France, Hôtel de Ville; in Italy, Palazzo Publico; in Holland, Stadhaus; an edifice in which all the municipal laws and regulations and the interests of a city are conducted

Tracery, that species of pattern-work formed or *traced* in the head of a Gothic window by the mullions being continued, but diverging into arches, curves, and flowing lines enriched with foliations.

"Each country (says Mr. Garbett in his 'Rudimentary Treatise on the Principles of Design in Architecture') has had its successive styles of tracery, and each has begun with the simple subdivision of one arch into two, and these sometimes into two again, filling up the space between the heads with a *circle*, as at Marburg; a *foiled circle*, as at Salisbury chapter-house, and the aisles of Cologne; or finally a *foil-circle*, as at Westminster, and the clerestory of Cologne, where it is subfoiled: thence proceeding to pack together such forms over an *odd* number of lights, to which the method of continual bisection would not apply, as at the aisles of York; and thus the first kind, which may be called *packed* tracery, became complete. Deviations from the principle of packing led to the general tracery, absurdly called '*geometrical*;' for all Gothic tracery is geometrical, none is hand-drawn. This beautiful purely *unmeaning* tracery was succeeded in all countries by the flowing loop or leaf, and then by the peculiar national After-Gothic. Germany, however, as it had been the first to perfect, was also the last to abandon the 'geometrical' tracery, which continued there, even into the fifteenth century, our Perpendicular Period. England and France, however, in the fourteenth century, abandoned the unmeaning for the flowing leaf-tracery; and this, notwithstanding its beauty, had hardly time to show itself before it was superseded, here by the perpendicular, and in France by the flamboyant. Hence it happens that of the three great classes of tracery,—geometrical, flowing, and perpendicular,—while the last is, as every one knows, by far the commonest in England, the most abundant kind in France is flowing (flamboyant), and in Germany geometrical, *i. e.* unmeaning.

"The unmeaning tracery of Germany is very beautiful, and generally partakes of the packed character; the following forms, which are the elements of German tracery, occurring very abundantly.



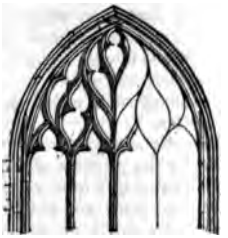
Elements of German tracery.

"The convex-sided triangle and square are placed in all positions indifferently, and the frameless trefoils and quatrefoils are frequently formed on the basis of these figures instead of the circle. The foilings and subfoilings, formed by a very narrow but deep chamfered member, leave their little spandrils (called *eyes* by our workmen) entirely open, thus producing almost the lightness of metal-work.

"The Germans seized on the idea of *growth*, and the budding and sprouting expression; but perhaps the French were most successful in increasing the aspiring expression: by a slight change in the prevailing forms of the flowing tracery, they converted the loops or leaves into flame-like forms, till the flamboyant buildings appeared not vegetating, as in Germany, but *blazing* from the foundation to the bristling finials. The difference between this style of tracery and our own flowing style (exemplified in the west window at York), is, that

English leaf-tracery.

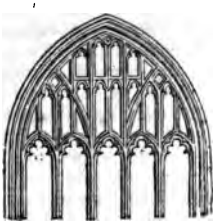
while the upper ends of our loops or leaves are round or simply pointed, *i. e.* with *finite angles*, the upper ends in France terminate, like the lower, in *angles of contact* (those formed by two curves that have a common tangent). It was necessary to the leafy effect that *the lower angles should be tangential; but to the flame-like effect*, that the *upper* ones should be so, even if the lower were



French flamboyant tracery.

finite; and hence some examples of flamboyant tracery, turned upside down, form a kind of leaf-tracery.

"Our countrymen, howev adopted a method which was conducive to the aspiring ex sion, and which conducted the a style less rich and certainly les



varied than any of the other After-Gothics. Erroneously supposing that an abundance of vertical lines would increase this character, they were led to convert all the flowing lines of the window tracery into vertical ones, to omit the capitals of nearly all the smaller shafts or shaftlets, thus converting what had been blank arcades into mere panels, and then to multiply, diminish, and extend these panels and endless repetition of vertical lines over every part of the interior, and, in florid buildings, even of the exterior."

Traction, in mechanics, is the act of drawing a body along a plane, usually by the power of men, animals, or steam; as when a vessel is towed on the surface of water, or a carriage moved upon a road. The power exerted in order to produce this effect is called the force of traction.

Numerous experiments have been made for the purpose of ascertaining the value of a force so exerted; and when men are employed to draw laden boats on canals, it is found that if the work be continued for several days successively, of eight hours each, the force of traction is equivalent to a weight of $31\frac{1}{9}$ lbs. moved at the rate of 2 feet per second, or $1\frac{1}{8}$ mile per hour, (it being understood that such weight is imagined to be raised vertically by means of a rope passing over a pulley, and drawn in a horizontal direction.) The force of traction exerted when, without moving from his place, a man pulls horizontally against a weight so suspended, is estimated at 70 lbs. The action of a horse in drawing a vessel on a canal is said to be equivalent to a weight of 180 lbs. raised vertically, as above supposed, with a velocity of $3\frac{1}{8}$ feet per second, or $2\frac{1}{4}$ miles per hour; but this estimate has been considered too high; and from experiments which have been made on the power of horses in waggons, carts, and coaches, on level ground, it is found that the force of traction exerted by a stout horse is equivalent to 80 lbs. raised at the rate of $4\frac{2}{3}$ feet per second, or 3 miles per hour. Tredgold considers that a horse exerts a force of traction expressed by 125 lbs. raised at the rate of $3\frac{2}{3}$ feet per second, or $2\frac{1}{2}$ miles per hour. A man or a horse can, however, double his power of traction for a few minutes without being injured by the exertion; and when the carriage is in motion, so that the friction on the ground is alone to be overcome, a horse can draw, during a short time, on a level road, a weight exceeding 1500 lbs.

The force of traction is found to vary nearly with the term $(w-v)^2$, where w is the greatest walking velocity of a man or horse when unresisted (6 feet per second, or 4 miles per hour, for a man, and 10 feet per second, or $6\frac{3}{4}$ miles per hour, for a horse), and v is the velocity with which the vessel or carriage is moved. From theoretical considerations it has been determined that the greatest effect is produced when the velocity of the object moved is one-third of that with which the man or animal can walk when unresisted.

If a wheel-carriage were situated on a level plane which opposed no resistance, it is evident that, whatever were the diameter of the wheels, the smallest conceivable power of traction applied to the axle would suffice to put the carriage in motion. But when a wheel in moving meets with an obstacle on the ground, that obstacle is pressed at the point of contact by a force acting in the direction of a line drawn to it from the centre of the wheel, and arising from that part of the weight which is supported by the wheel, together with the force of traction; therefore, by the 'resolution of forces,' the ratio between the resistance which is to be overcome by the moving power and the weight on the wheel will become less as the diameter of the wheel is increased: also the most advantageous direction in which the force of traction can be exerted is perpendicular to the line of pressure drawn from the centre of the wheel to the obstacle. But the height of the wheels cannot exceed certain limits, depending on the use to which the carriage is applied; and when the latter has four wheels, the height of those which are in front must be such only as will allow it to be turned round within

a given space: also, when a horse is employed to move a carriage, attention must be paid to the conditions under which his power may be advantageously exerted.

It was first observed by M. Deparcieux, and published in the 'Mémoires de l'Académie des Sciences,' 1760, that horses draw heavy loads rather by their weight than by their muscular force. Sir David Brewster has also remarked, that when the resistance is great, a horse lifts both its fore-feet from the ground; then, using his hinder-feet as a fulcrum, he allows his body to descend by its weight, and thus overcomes the obstacle: and it may be added, that when this action takes place with a two-wheeled carriage, if the loading is disposed so that some portion of it may press on the horse's back, the effect of the animal's weight will thereby be increased. Now, if the traces, or the shafts of the carriage, were attached to the horse's collar, near his centre of gravity, a line imagined to be drawn from the latter point to his hinder-feet may represent his weight, and a line drawn perpendicularly from his feet upon a plane passing through the traces or shafts may represent the lever of resistance: but while the former line remains the same, this lever becomes less as the plane of traction (that of the traces or shafts) inclines more upwards from the wheel; and therefore, in order that the power of the horse may be advantageously applied, the diameter of the wheel should be as small as is consistent with other circumstances.

Experiments have shown that when the angle of traction, as it is called, that is, the angle which the plane of the traces makes with the road on which the carriage is moving, is 15 or 16 degrees, a horse pulls with good effect; and the height of the points at which the traces are attached to a horse's collar being about 4 feet 6 inches from the ground, it follows that, in order to obtain this inclination, the lower extremities of the traces or shafts should be 2 feet 3 inches from the ground. In general, however, in two-wheeled carriages the height of these extremities is about 3 feet.

As an example of the force of traction exerted by steam, it may be stated, that on a level line of railway, an engine with an 11-inch cylinder, and having an effective pressure of 50 lbs. per square inch in the boiler, drew 50 tons at the rate of 30 miles per hour, working 10 hours daily; and that the same engine, with an equal pressure in the boiler, drew 160 tons at the rate of 15½ miles per hour.

Trail, a running enrichment of leaves flowers, tendrils, &c., in the hollo mouldings of Gothic architectur

Trail-boards, in ship-building, the carved work between the cheeks; that which is fastened to the knee of the head

Trailing springs, the springs fixed on the axle-boxes of the trailing wheels of a locomotive engine, which bear slightly against the side frames, so as to leave as much weight as possible upon the driving springs, and to assist in deadening any shock which may take place

Trailing wheels, the wheels placed behind the driving wheels of a locomotive engine

Trammel, a rod of iron or wood, with sliding pieces having points, which can be fixed at any distance apart; used for drawing large circles, or setting off distances

Transept, the transverse portion of a cruciform church; that part which is placed between and extends beyond those divisions of the building containing the nave and the choir

Transit, a term expressing the passage of a railway train, &c. In astronomy, the passage of any heavenly body over a larger one, as Mercury or Venus over the sun.

Transition, as applied to the architecture of the middle and later ages, the progress of changing from one style to another. There were several periods of transition: Romanesque to Saxon, Norman to Early English, Early English to Decorated, from the Decorated to the Perpendicular to that of the Tudor and to that of the Elizabethan age.

Transom, a horizontal mullion or cross-bar in a window. The most ancient examples are found in the Early English style.

Transom, in carpentry, a thwart-beam or lintel over a door. In ship-building, certain timbers extending across the stern-post of a ship, to fortify and strengthen it. In mathematics, the vane of an instrument called a cross-staff, being a piece of wood fixed across, with a square socket upon which this slides.

Transparency, that quality of certain bodies by which they transmit the rays of light, in contradistinction to opacity

Transposition, in music, the changing a tune or lesson, and putting it into a higher or lower key or clef

Transtra, horizontal timbers in the roof of a building. The term is applied to the transverse beams of a gallery which extend from side to side and connect the ribs, in the same manner as these horizontal pieces connect the axis or principals of a roof.

Transverse, in geometry, something that goes across another, from corner to corner, like the diagonals of a square or parallelogram

Transyte, a narrow or triforial passage

Trapezium, in geometry, a plane figure contained under four right lines, of which neither of the opposite sides are parallel

Trapezoid, an irregular figure whose four sides are not parallel, resembling a trapezium

Traveller, in navigation, a sort of thimble, whose diameter is much larger, in proportion to the breadth of its surface, than the common ones: it is intended to facilitate the hoisting and lowering the top-gallant yards at sea

Travelling crane, a crab fixed on a carriage which may be moved upon rails across a building, and the cross-rails, together with the carriage, moved lengthwise upon other rails fixed at or near the top of the building

Traverse sailing, in navigation, is the variation or alteration of a ship's course occasioned by various causes; or it is a compound course in which several different courses and distances are known

Traverse-table, in navigation, is the same as a table of difference and departure, ready calculated for any distance under 100 miles

Treadle, a lever or frame connected by a rod to the crank of a foot-lathe, to give motion to the crank-shaft: it is pressed down by the left foot of the turner, and raised by the centrifugal force of the fly-wheel or large pulley which is fixed on the shaft

Treasury, a building or an apartment where money or valuables are deposited

Tree-nails, or *Trennels*, in ship-building, long cylindrical wooden pins

Trefoil, an ornament formed by mouldings so arranged as to resemble the trefoil or three-leaved clover

Trellis, a gate or screen of open work; lattice-work either of metal or wood

Trench, a ditch; a defence for soldiers. Trenches, approaches, or attacks, are works carried on by besiegers, with parapets for the men to gain ground and draw near a citadel or fortification: if the ground be hard or rocky, trenches are raised above it with fascines, bags of earth, &c.; but if the earth can be easily dug, then a ditch or way is sunk, and edged with a parapet next to the

besieged, the depth being commonly about six or seven feet, and the breadth seven or eight feet.

Trend, in navigation, to bend, to lie in a particular direction

Trestle-trees, in ship-building, two strong bars of timber fixed horizontally on the opposite sides of the lower mast-head, to support the frame of the top and the weight of the topmast

Tret, an allowance in weight for waste or impurities

Triangle, a figure bounded by three sides, and consequently containing three angles. Triangles are of the several kinds, plane or rectilinear, spherical, and curvilinear.

Tribometer, in mechanics, a term applied to an instrument for estimating the friction of metals

Tribunes, magistrates among the old Romans, chosen to preserve the privileges and secure the liberties of the people against the power and encroachments of the nobles: at first their number was but two, and these afterwards associated three more to them, whose number was in process of time increased to ten. Their authority was so great that they could assemble the people for what purposes they pleased, hinder the deliberations of the senate, approve or annul its decrees, summon the other magistrates before the people, and also their own colleagues and associates: they went so far as sometimes to imprison consuls and fine dictators. At first their jurisdiction reached but a mile out of the city of Rome, but some time afterwards it was extended into the provinces. These officers kept their doors open day and night, to receive such of the common people as sought for shelter with them. The office grew into so much authority and honour, that the greatest men in the state chose it, and by clashing with the consuls and senate occasioned great tumults. There were also military tribunes, but their powers were more limited.

Tribute, in mining, a proportion of the ore which the workman has for his labour. Tributers generally work in gangs, and have a limited portion of a lode set them, called a 'tribute pitch,' beyond which they are not permitted to work, and for which they receive a certain portion of the ore, or so much in the pound as agreed upon in value of what they raise.

Triclinium, the eating-room of a Roman house; so called because in general it contained couches upon which the ancients or their guests reclined at their meals. The term was also applied to the couches themselves.

Triforium, the gallery or open space between the vaulting and the roof of the aisles of a church, generally lighted by windows in the external wall of the building and opening to the nave, choir, or transept over the main arches. In the Temple church it is built around the nave, and has a curious and singular effect.

Triglyphs, in architecture, ornaments repeated at equal intervals in the Doric frieze. Each triglyph consists of two entire gutters or channels cut to a right angle, called *glyphs*, and separated by their interstices, called *fermona*, from each other as well as from two other half-channels that are formed at the sides.

Trigonometry, the art of measuring triangles, or of calculating the sides of any triangle sought, either plain or spherical. (See *Ordnance Survey*.)

Trim, in navigation, the best posture of a ship's proportion of ballast, arrangement of sails, and position of masts, with a view to her sailing well

Trimmer, a piece of timber inserted in a roof, floor, wooden partition, &c., to support the ends of any of the joists, rafters, &c.

Tringle, in architecture, a name common to several little square members or ornaments, as regulets, lestets, and platbands

Tripod, any utensil or article of furniture supported upon three feet

Triptic, a tablet in three divisions, to open and shut, the two outer folding over the centre one when closed

Trisection, the division of a line, an angle, &c. into three equal parts

Trochilus, a hollow moulding; also called *scotia;* constantly occurring in the bases of the classical orders of architecture

Trochoid, in geometry, a particular description of curve generated by the motion of a wheel

Tropics, two lesser circles on the globe or sphere; one on each side, distant 23½° from the equator, which are the bounds or limits of the sun's deviation from the equator: at his approach to these circles the sun seems to stand still for a few days, and then returns towards the equator again: that on the north side is called the tropic of Cancer, and, when the sun is there, makes our longest day; and that on the south side is called the tropic of Capricorn, and causes the longest night.

Troubles, in mining, faults or interruptions in the stratum

Trucks, in navigation, circular flat pieces of elm, with a small sheave on each side, fixed upon the upper end of flag-staffs, and used to reeve the halliards

Truncated, in geometry, a pyramid or cone, the top or vertex of which is cut off by a plane parallel to its base

Trunk engine, a marine steam engine used for driving a propeller: the cylinder is fixed horizontally

Trunking, the process of extracting ores from the slimes: the ores subsequently undergo the process of racking and tossing

Trunnions, knobs of metal in pieces of ordnance which project from the sides and bear the guns on the cheeks of the carriage

Truss, the collection of timbers forming one of the principal supports to a roof, framed together to give mutual support and to prevent straining or distortion from the superincumbent weight

Truss, to strain, support or keep tight: a trussed roof is one which by means of the tie-beams, rafters, king-posts, &c., is strained, or held together in its proper position

Trussing, in carpentry and ship-building, a series of diagonal braces disposed in triangles, the sides of which give to each other a mutual support and counteraction

Trussing-beds, in Tudor times, were beds which packed into chests for travelling: in cases of frequent removal, they must have been found very convenient. John of Ghent seems to have always slept in such beds.

Tub, a cast-iron cylinder put in the shaft instead of bricking, for the purpose of beating out the water and making it rise to a level

Tubes, in locomotive engines, are of brass or iron, about two inches outside diameter. They are of the same length as the boiler, and fixed in it by a ferrule driven in at each end, which makes them steam-tight. They are surrounded with water externally, and internally open to the atmosphere by the chimney. The heated gases and smoke from the fire pass through them, and they are thus the means of rapidly generating steam. The number of tubes in boilers varies from 60 to 70 up to above 200, according to the power of the engine.

Tube ferrules, in locomotive engines, slightly tapered hoops, one of which is driven in at each end of each tube, to fix it securely in the boiler: formerly they were made of steel and iron; now, cast-iron ferrules are found to answer very well

Tube plugs, in locomotive engines,

are formed of tapered iron or wood, and used for driving into the end of a tube when burst by the steam

Tube plug-ram, in locomotive engines, a long rod with a socket end, into which the plug fits, and is thus driven into the burst tube, and the plug-ram withdrawn

Tubular Boilers. Boilers of an angular, prismatic, or indeed any but a cylindrical form,—or even then if not made of wrought metal,—become the peculiar seat of danger in high-pressure engines; and all sorts of safety apparatus, as well for preventing too great a pressure as for avoiding other sources of danger, are but uncertain in their operation, and not to be depended upon. The great object to be sought is so to construct boilers that their explosion may not be dangerous in its result.

This condition has been approximated to by the invention and application of tubular boilers; but it would seem that these have been suggested rather by the necessity of providing, for many technical purposes, and particularly for steam carriages, boilers of less content and weight, than by the desire of removing or lessening danger from explosion. Tubes should have that form which is best adapted to resist pressure, viz. the cylindrical. If they are of small diameter, of not too great thickness, and of suitable material, they may be made to carry out the before-named principle; *i. e.* they themselves, in case of bursting, will not cause any dangerous consequences to the neighbouring persons or property. This has been amply proved by experience.

Unfortunately, however, there are no tubular boilers which satisfy all conditions required. The subject is often mentioned as one of little difficulty, easy of decision, and unencumbered with practical obstacles; but such is the language only of the prejudiced and the inexperienced. To arrive at the truth, it must be sought with long-continued perseverance, and with no small share of physical knowledge, as the subject is beset with difficulties on every side.

It becomes a most complex problem to construct a tubular boiler for a large supply of steam, by reason of the difficulty of arranging and connecting the great number of tubes it must contain into one convenient whole. The modern English locomotive boilers cannot be legitimately called *tubular* boilers, because they fail altogether in the grand distinguishing quality of all such,—namely, the small diameter of the generating apparatus: the tubes of these boilers are nothing more than a splitting-up or subdivision of the fire-tube of the Trevithick steam-carriage boiler. From their great outer diameter, locomotive boilers do not avoid the evil of the old capacious form, and therefore do not diminish the objection to it: they have also a defect in the close proximity of the tubes to each other, whereby the water space between them is rendered too confined, and the heated tubes become liable to be laid bare of water. This circumstance gives the key to the well-known fact, that the tubes become so soon destroyed, or, at least, require constant repair, and add to the mischief occasioned by their expansion, through their connection with the end plates of the cylindrical part of the boiler. It is evident that from the passage upwards of the steam formed among the lower tubes, the upper ones must be most liable to be uncovered with water; while these, being exposed to the hottest part of the fire current, are most likely to receive damage therefrom.

A tubular boiler ought to preserve, as much as possible, the tubular form in all its parts; or, at least, the larger portions ought to

be cylindrical, and not of too great diameter, or should be so strongly made that the tubes should form the weakest part of the whole boiler. The tubes themselves should be of such diameter, and be constructed of such metal, that in case of their actual bursting, no dangerous explosion may ensue. This, however, is only possible when their thickness is so small, and the metal of such a kind, that bursting takes place by a comparatively small internal pressure, and is followed by only a ripping open of the tube, and not a scattering about of massive fragments. Under all circumstances, however, the tubes must be the sole generating vessels: they alone must receive the action of the fire, and be exposed to its destructive influence. All other and larger vessels, or parts connected with the tubes, should be most carefully protected from not only this but all other dangerous influences, in order that they may remain in their original proved condition of strength.

Only such a tubular boiler as fulfils all these conditions can be called a safe one. In its use there is no further danger from high-pressure steam, and near it its owner may repose undisturbed by a care for the safety of life or property.

The requisites in the use of the tubes are the following:—They must be placed in such a position, with regard to the furnace, that the flame may act upon them in the most favourable manner, and that the heat may be absorbed as completely as possible.—They must have such a proportion between their length and diameter, that neither the ebullition in them may become too violent, and the water be thereby ejected from them, nor that they become warped or made crooked by the heat.—They must properly convey away all the generated steam, and be regularly supplied with water.—They must be connected with the main part of the boiler in such a manner, that in case of a rupture of one of them, the whole content of water and steam cannot suddenly and dangerously discharge itself.—They must lie so deep under the general water-level of the boiler (in the receivers or separators), that some considerable sinking of the water may be allowed to take place without leaving any of them empty; and in case the latter effect should occur, such tubes must first be emptied as are least exposed to the heat of the furnace.—Lastly, they must be connected with each other in such manner that no destructive expansion may be allowed to take place, and that all may be easily and conveniently cleansed of the earthy matters deposited in them.

The larger portions of the boiler, or receiving vessels, may themselves consist of tubes of a larger diameter, or may form flat chambers, constructed of a strength to withstand a very high pressure (say 400 to 500 lbs. per square inch): this involves no difficulty. The diameter of the receivers should not, where it can be avoided, exceed 16 inches, and they should be constructed of plate iron of at least ⅜ of an inch thick, securely and exactly riveted together into a cylindrical form. When it is necessary that they should be capacious, their length should be increased, and not their diameter beyond that specified, or their number should be greater. Their covering lids may be flat and of cast iron, but of considerable thickness (1½ to 2 inches), and these must be connected to the cylinders securely, and in such a way that they may be easily taken off when cleaning is required. They must, under all circumstances, be entirely removed from all strong action of the fire, and must at most be exposed only to such currents as have discharged

the greatest portion of their heat against the generating tubes. In order to preserve them from rust, their internal and external surfaces may be covered with several coats of oil-varnish, and the coating renewed, at least on the inside, every year.

Since these receivers or larger parts of the boiler usually serve as separators, and as means of connection between the generating tubes, they must be perfectly adapted to fulfil these purposes. As separators, they must efficiently separate the steam from the water, so that none of the latter may penetrate into the working parts of the engine; and to this end the water surface in them must be of sufficient extent. In order that the water may not rise to a dangerous height in them by violent ebullition in their tubes, their water space must bear a certain proportion to that of the tubes and the other parts of the boiler. The steam room in them must also be proportioned to the content of the engine cylinder; so that the pressure may not be too much lessened by the discharge into the engine, and a foaming of the water thereby be caused.

Tubular Bridges are those in which the requisite strength and rigidity are obtained by disposing the materials in the form of a horizontal tube, through which the passage is formed for the traffic. They are to be distinguished from trussed bridges, which, when constructed of timber and covered over, as in several of the American bridges, resemble a tube, or two or more parallel tubes, being formed entirely without trussing, and therefore admitting of construction with iron only. Tubular bridges are to be regarded as an original and highly important invention, admirably adapted for spanning wide spaces, *and affording* all required *strength with a positive* minimum of depth. In all arched bridges some portion of the space below, or head room for navigation, is sacrificed by the depending haunches; or, on the other hand, if the roadway is made to correspond with the chord of the arch, the crown is necessarily elevated to a considerable height, and additional weight involved in sustaining and preserving the position of the higher parts of the structure. Hence *flatness*, or the reduction of the total depth, has always been a desideratum in the designing of bridges, and scientific skill and boldness have achieved several examples in which this property is attained in a much greater degree than it was once thought safe and prudent to attempt. The wrought-iron tubular bridge, however, is safely constructed with a total depth of $\frac{1}{15}$th of its span, and with sufficient strength and rigidity to sustain great loads, such as railway trains, without sensible vibration or deflection. For bridges of small span, the tubular principle may be adopted in the construction of malleable-iron girders, each of which is itself a rectangular tube of small section, the roadway being thus supported upon two or more of these tubular girders arranged in parallel positions, and at some distance apart. In these bridges a level roadway is formed with a small depth, but the roadway and traffic occupy an additional depth; whereas in the tubular bridge, as constructed for large spans, the depth of the tube itself comprises the entire depth of the structure, and it may therefore be considered as a vast hollow girder, *through* which the roadway is formed. Mr. Robert Stephenson appears to have first suggested the idea of forming tubular bridges; and that over the Conway, erected on the line of the Chester and Holyhead Railway, was completed and opened in 1849. This bridge consists of two tubes, placed parallel to each other over

a clear span of 400 feet. Each tube, with its castings, &c., weighs about 1300 tons, and is constructed of plate iron riveted upon malleable-iron ribs, the section of the tube being a rectangle about 30 feet in height and 15 feet wide. The sides, top, and bottom of the tubes consist of long narrow plates of malleable iron, varying in length up to 12 feet, and in width from 1 foot 9 inches to 2 feet 4 inches: they vary in thickness from ⅜ to ¾ inch. The internal ribs are of T-iron, 3½ inches deep, and placed at intervals of 2 feet. A depth of about 1 foot 9 inches across the tube is occupied at top and bottom with narrow cells formed with plate iron and L-iron corner pieces, all firmly riveted together. These cells are for the purpose of giving the requisite stiffness to these parts of the tube, and are closer together at the top than at the bottom of the tube, as the tendency of a load is to compress the upper part and distend the lower part of the structure, and wrought iron is, it appears, much better able to resist extension than compression. In his report to the Directors of the Chester and Holyhead Railway, their Engineer, Mr. Stephenson, thus referred to some of the results of the experiments which were made in order to determine the form and proportions for his proposed tubular bridge over the Menai Straits. "The first series of experiments was made with plain circular tubes; the second with elliptical; and the third with rectangular. In the whole of these this remarkable and unexpected fact was brought to light, viz. that in such tubes the power of wrought iron to resist compression was much less than its power to resist tension,—being exactly the reverse of that which holds with cast iron: for example, in cast-iron beams for sustaining weights, the proper form is to dispose of the greater portion of the material at the bottom side of the beam; whereas with wrought iron, these experiments demonstrate beyond any doubt that the greater portion of the material should be distributed on the upper side of the beam. We have arrived, therefore, at a fact having a most important bearing upon the construction of the tube; viz. that rigidity and strength are best obtained by throwing the greatest thickness of material into the upper side. Another instructive lesson which the experiments have disclosed is, that the rectangular tube is by far the strongest, and that the circular and elliptical should be discarded altogether."

Another tubular bridge, similar to that at Conway, is now (1856) in course of construction over the Menai Straits, near Bangor, intended to exceed the Conway bridge in extent, consisting of two water bays of 460 feet span each, and two land bays, one at each end, of 230 feet span each.

These grand bridges differ little less in the mode of constructing and erecting them than in their design from ordinary bridges of stone, timber, or iron. Thus the larger tubes over the water-ways are put together adjacent to their final resting-place, and when complete as tubes, they are launched upon pontoons, floated to the piers and raised to their places complete and entire by hydraulic presses operating at each end. For this purpose of raising, strong temporary frames of cast iron are fitted to the ends of the tube, and made fast to solid bar-link chains, the upper ends of which are forced upwards by successive lifts of the hydraulic press, each lift being 6 feet, and the ends of the tube being packed up as the raising proceeds. One end of each tube is permanently laid upon cast-iron rollers to admit of the changes of length produced by variations of temperature

ture. For the purposes of the railway, transverse plates of iron are fixed edgewise on the bottom of the tube, and support longitudinal balks of timber, upon which the rails are laid. The height of the Conway Bridge is 18 feet at the bottom of the tubes above high water; that over the Menai Straits, called the 'Britannia' Bridge, 102 feet above the same level.

Tudor Badges. The badges of the house of Tudor were either assumed or derived from descent or alliance: the red rose was the peculiar distinction of the house of Lancaster, and was borne by Henry VII. as Earl of Richmond. The portcullis was the badge of the Beaufort branch of the same family, assumed by the descendants of John of Ghent, born in the castle of Beaufort; and agreeably to heraldic simplicity, a part of the castle, its most prominent feature, was depicted for the whole. The fleur-de-lis was also a badge of the house of Lancaster, and was introduced, together with the rose, in the border of Henry's arms, as Earl of Richmond. Descended from Cadwallader, the last of the British kings, and deriving from him the name of Tudor, he assumed the badge of the red dragon, Cadwallader's ensign. After the battle of Bosworth Field, Henry took as a badge the hawthorn bush, crowned, in allusion to the circumstance of the crown being found in a hedge, whence it was taken and placed on his head. The red rose, or rose of Lancaster, he placed on the sunbeams, as the white rose had been by the head of the house of York. This monarch assumed the Tudor rose, or the red rose charged with the white, as emblematical of his united claims to the throne by his marriage with Elizabeth, the daughter and sole heir of Edward IV. Upon the marriage of Prince Arthur with Catherine of Arragon, he adopted, in compliment to her, the badges of her house. The castle was an ancient badge of the house of Granada. The sheaf of arrows was assumed by the house of Arragon on the conquest of Granada, which had been achieved by the superiority of the Arragonese archers. The rose dimidiated with the pomegranate was adopted as being symbolical of the junction of England and Spain. The phœnix in flames was assumed by Edward VI., in allusion to the particular nature of his birth, and was granted by him to the family of Seymour. A white falcon, crowned, and holding a sceptre, was assumed by Queen Anne Boleyn as her peculiar badge, and was continued by her daughter, Queen Elizabeth. The harp, an ancient badge of Ireland, was used by Queen Elizabeth. The rose environed by the garter, with its motto, was a badge of several branches of the Tudor family. All these badges were represented crowned, when borne by the monarch, and were occasionally placed between the royal supporters.

Tudor Style of Architecture, a continuation of the Perpendicular Style, merging into a peculiarity in the time of Henry VIII., when it was much applied to domestic purposes and to edifices for collegiate halls, and several foundations for educational and charitable uses, thus appropriating the proceeds of monastic revenues. The mansions of the Tudor period usually consisted of an inner and base court, between which stood the gate-house. The principal apartments were the great chamber, or room of assembly, the hall, the chapel, the gallery for amusements, on an upper story, running the whole length of the principal side of the quadrangle, and the summer and winter parlours. Of quadrangular houses, the seats of the Bishops of Carlisle, Cowdry, Halnaker, &c., may be taken as fair examples. In

Lamb's 'Studies of Ancient Houses' (a book of a convenient size and price) are some fine examples in this style, but of a smaller kind. Very many splendid examples of larger dimensions of halls, mansions, &c., still exist scattered over the country. Lincoln's Inn Hall, newly built in this style, is the most successful practice probably that has yet been accomplished,—done with all the spirit and grace and the picturesque without sacrifice of any principle of this admired style.

Tufa, a calcareous earth, composed of broken and concreted shells, or the deposit from water impregnated with lime

Tugs, in mining, hoops of iron fastened to the covers to which the tackles are affixed

Tugs, steam, small steam vessels employed in towing other craft

Tulip wood, the growth of the Brazils, is frequently unsound in the centre, very handsome, but soon fades: it is used in turnery and Tunbridge ware

Tumbling-home, in nautical language, the falling into midships of the top-side above the main breadth, to bring the upper deck guns nearer the centre of the ship

Tummals, in mining, a great quantity or heap

Tumulus, a heap, or mound of earth, sometimes called a burrow, used for the burial of the dead previous to the Roman invasion of Britain

Tunnel, a large and subterraneous arch, driven through an elevation or hill, or under a river, for the passage of boats, carriages, &c.

Among the costly and laborious works of a railway, its tunnels occupy the first place. Like mining, and all other subterranean operations, the construction of a tunnel can be but little aided by mechanical appliances; it chiefly requires hard manual labour, exercised under circumstances which do not admit of that thorough superintendence which promotes economy, and, moreover, liable to unforeseen interruptions, of surmounting which neither the manner nor the expense can be predetermined. Thus the Kilsby tunnel, on the London and Birmingham Railway, was estimated to cost about £40 per yard lineal; whereas its actual cost was £130 for the same length, owing to its intersecting a quicksand, which the trial borings had escaped. Thus a vast expense was necessarily incurred in setting up and working pumping machinery in order to dry the sand. The pumps brought up nearly 2000 gallons per minute, and were working during a period of nine months. The quicksand extended over a length of about 450 yards of the tunnel. The Box tunnel, on the Great Western Railway, excavated through oolite rock and being lined with masonry only through a portion of its length, cost upwards of £100 per lineal yard. The Bletchingley tunnel, on the South Eastern Railway, cost £72 per lineal yard; and the Saltwood tunnel, on the same line of railway, cost £118 per lineal yard. This greater cost in the latter work was occasioned by the great body of water in the lower green-sand which the tunnel intersects.

The method of proceeding with tunnelling depends mainly upon the kind of material to be excavated. This having been generally ascertained by borings and trial shafts, the work is commenced by sinking the working shafts, which must be sufficiently capacious to admit readily of lowering men and materials, raising the material excavated, fixing pumps, and also for starting the heading of the intended tunnel when the required depth is reached. Besides the trial and working shafts, air-shafts are sunk for the purpose of effecting ventilation in the works below.

The working shafts are made cylindrical, and from 8 to 10 feet internal diameter: 9 feet is a favourite dimension. They are of brick-work, usually 9 inches thick, and carried up 8 or 10 feet above the surface of the ground, finished with stone coping. These, and all other shafts, rest upon curbs of cast iron, fitted into the crown of the tunnel, and forming a level base for the shaft. The air-shafts are of similar thickness and form, but usually about 3 feet internal diameter. They should not be allowed to be sunk near to the working shaft, or at a less distance than 50 yards from it. All the shafts are, of course, sunk on the centre line of the intended tunnel. In the Bletchingley tunnel, the trial shafts, 6 feet diameter in the clear, 9 inches thick, and 35½ yards deep, cost £6 per yard down through the Weald clay. A similar shaft in the Saltwood tunnel, 25 yards deep, cost £4. 15*s*. per yard down, in the lower green-sand. Horse-gins are usually employed in raising and lowering the materials, &c., and also in drawing the water up the shafts, unless large pumps are used and worked by steam-power. The engineer calculated the expense of horse labour thus exercised at 2¾*d*. per ton lifted 100 feet high, and including the boy to drive the horse.

The number of working shafts will depend chiefly upon the rate of speed with which the work is required to be accomplished. With plenty of men, horses, materials, and plant, the work is much facilitated by sinking extra shafts, which will usually well repay their cost. The Watford tunnel, 75 chains in length, on the London and Birmingham Railway, was specified to be worked with six shafts, not less than 8 feet diameter within the brick-work, and 9 inches thick; the brick-work moulded to fit the circumference of the shaft, and laid in two half-brick rings; an air-shaft at a distance of 50 yards on each side of each working shaft, and not less than 3 feet 6 inches diameter inside; the arch and side-walls of the tunnel, usually two bricks thick, and the invert, one and a half brick, except in places where the stratum passed through seemed to require an increased, or admit a diminished thickness. The form of the top of the tunnel is nearly semicircular, supported by curved side walls standing on stone footings or skew-backs, which rest on the invert forming the base of the tunnel. The ends of the tunnel are formed with wing-walls. The brick-work at the ends of the tunnel is bound by wrought-iron rods 100 feet long, secured at each end in a cast-iron rim or plate built into the brick-work.

The Northchurch tunnel, which is 16 chains in length, on the same line of railway, was worked with two shafts, each 9 feet diameter. In the construction of this tunnel, a heading was driven, 4 feet wide and 5 feet high, throughout the entire length of the tunnel, and between two shafts sunk for this purpose, one near each end of it. It was specified that this heading should be driven through before any part of the tunnel was commenced, and supported and kept open during the execution of the entire work by sufficient timbering.

In commencing the works of the Saltwood tunnel, already referred to, great difficulty was encountered from the great quantity of water in the lower green-sand which the tunnel intersects. The course adopted was to make a heading or adit quite through the hill on a level with the bottom of the tunnel, in which the water was collected and drained off. The size of this, and of the Bletchingley tunnel, is 24 feet wide at the broadest part, 30 feet including the side walls; 25 feet high in the

clear, 30 feet including the invert and top arch, or 21 feet clear above the level of rails. The brick-work in the top arch and walls is from two and a half to four bricks in thickness; the invert three bricks thick.

When water occurs in the sinking of the shafts or the building of a tunnel, the back of the brick-work should be well lined with puddle, and Roman or metallic cement substituted for mortar. The whole of the Kilsby tunnel, on the London and Birmingham Railway, was built in either Roman or metallic cement, and the thickness of the brick-work is chiefly 27 inches. This tunnel is about 2423 yards long, and its length is divided by two ventilating shafts, cylindrical, and 60 feet in diameter. These shafts are 3 feet thick in brick-work, laid in Roman cement throughout. They intersect the line of the tunnel, and thus form curved recesses by that portion of their circumference which extends beyond the width of the tunnel on either side. These shafts were built from the top downwards, by excavating for small portions at a time, from 6 to 12 feet in length and 10 feet deep.

The Box tunnel, on the Great Western Railway, intersects oolite rock, forest marble, and lias marl, with fullers' earth. Eleven principal shafts, generally 25 feet in diameter, and four immediate shafts 12 feet 6 inches, were sunk for the purpose of carrying on the works of this tunnel, the entire length of which is 3123 yards, or a little more than 1¾ mile. The section of the tunnel was designed to be 27 feet 6 in. wide at the springing of invert, and 30 feet at a height of 7 feet 3 inches above this; clear height above the rails 25 feet. As a great portion of the tunnel was constructed by mere excavation, and without masonry, these dimensions were in some cases departed from, in order to clear away loose portions of the stone and secure solid surfaces. Where brick-work is used, the sides are seven half-brick rings in thickness, the arch six, and the invert four. During the construction, the constant flow of water into the works, from the numerous fissures in the rock, compelled pumping on a most expensive scale to be adopted. From November, 1837, to July, 1838, the works were suspended, the water having gained so completely over the steam pump then employed, that the portion of the tunnel then completed was filled with water, as also a height of 56 feet in the shafts. A second pump, worked by a steam engine of 50 horse-power, was applied, and enabled the works to be resumed.

When the working shafts are sunk sufficiently deep, a narrow heading is excavated, from 6 to 12 feet in length, 3 or 4 feet wide, and high enough for a man to work in. The top of this heading should be as much above the intended soffit of the tunnel-arch as to admit the thickness of the brick-work, besides the bars of timber and boarding by which the roof of the heading is supported, and several inches should be allowed for the settlement of the timber, which always occurs as the excavation is proceeded with, and before the brick-work can be got in.

This allowance is of the utmost importance, as without it the brick-work will, when the settlement occurs, be forced down, and can only be raised to its proper level by removing the superincumbent earth piecemeal, and at great cost. The bars, and poling and packing boards, are introduced in the most convenient manner, according to the nature of soil excavated, and the degree in which it requires support, or may be safely left unsupported.

The heading is extended on either side by first cutting narrow gap-

horizontally, or rather dipping downwards in directions following the intended form of the tunnel-arch. Into these gaps, crown bars are laid lengthwise, and supported upon props; and poling boards are put in between them, to retain the earth at the sides of the excavation, when extended. When the heading has thus been widened by excavating right and left, and a sufficient length cleared, the centerings are fixed, and the brick-work is commenced. As this proceeds, the earth is carefully rammed behind it, and all vacancies filled up, to prevent any subsequent settlement of the surrounding earth upon it. The crown bars which are inserted in the heading, and always during the excavations, are not invariably removed. If they can be drawn forward as the heading advances, without disturbing the adjacent ground, and the spaces filled up with broken stone, or other suitable material, no objection can arise; but otherwise they should be allowed to remain, and be built in. The whole of the operations require carefully regulating, so that none of them shall advance too rapidly for those which follow. Contractors are therefore usually restricted to carry the excavation not more than 6 or 8 feet in advance of the brick-work, or less, if so directed by the engineer, should any change occur in the strata which he thinks may require such precaution. When the faces of two contiguous excavations approach within about 50 yards of each other, a heading should be driven quite through the intervening ground, and the workings joined before the whole excavation and brick-work are proceeded with.

Experience has proved that the *quality* of the bricks used in tunnel-work is of the utmost importance. If these contain lime, on which the weather operates injuriously, the face of the work soon decays, and requires extensive repair or restoration. This was the case with the Beechwood tunnel on the London and Birmingham Railway, which in less than three years was considered to be in an unsafe condition, owing to this cause. The remedy adopted was of the most complete character; it consisted in an entirely new lining of brick-work, 9 inches thick. This tunnel is about 302 yards long, and passes through strata consisting of alternate layers of rock and marl, abounding with springs of water. By judicious arrangement, the lining was completed in forty days. The traffic being diverted to one of the two lines of rails which are laid in the tunnel, and a hoarding erected along the centre, the casing was carried up on one side to the height of 4 feet 6 inches above the springing. At this point a course of York paving, 4½ inches thick, was bonded into the original work, and the new work was securely attached beneath it with wedges of iron; half-brick toothings were also inserted in chases cut 2 feet 3 inches apart in the original work. The traffic was then turned into the line on the side thus cased, and the other wall was similarly treated. Bearers were then fixed 6 feet apart over head, and a close flooring laid upon them. Upon each bearer a pair of ribs was raised, and keyed stays and laggings were fixed, and the brick-work, in English bond, brought up on each side simultaneously, leaving a central space 2 feet 3 inches wide at the crown. A moveable centre of this length was used to close in this space with two half-brick rings. Vertical chases, 4½ inches square, besides those cut for the toothings, were made in the face of the old walls previous to lining. These formed permanent drains, terminating in the culvert beneath the centre of the tunnel.

Turbine Water-wheel. The horizontal water-wheel so called, as used in France and Germany, was invented by M. Fourneyron: the water enters at the centre, and, diverging from it in every direction, it then enters all the buckets simultaneously, and passes off at the external circumference of the wheel. The pressure with which the water acts on the buckets of the revolving wheel is in proportion to the vertical column of water, or heights of the fall, and it is conducted into these buckets by fixed curved girders secured upon a platform within the circle of the revolving part of the machine. The efflux of the water is regulated by a hollow cylindrical sluice, to which stops are fixed, which act together between the guides, and are raised or lowered by screws that communicate with a governor, so that the opening of the sluice and stops may be enlarged or reduced in proportion as the velocity of the wheel requires to be accelerated or retarded. Turbines may be divided into high-pressure and low-pressure engines. High-pressure turbines are particularly available in situations such as often occur in hilly districts where high falls of water may be commanded, and the character of the site affords facilities for constructing reservoirs, so that a constant supply may be insured. In these cases the height of the column of water will compensate for the smallness of its volume, and the high-pressure turbine will be found applicable with great advantage to the grinding of corn, crushing ores, working threshing machines, or actuating other machinery. The low-pressure turbines produce great effect with a head of only nine inches, and are suitable for situations in which a large bulk of water flows with little fall. The results of an investigation by MM. Arago, Prony, Gambey, and Savary, appointed by the French des Sciences to report bines, are given in a t M. Morin on the subjec as follows:

1. That these wheels cable equally to great an falls of water. 2. That t mit an useful effect, equ 70 to 78 per cent. of the total moving force. 3. may work at very diffe cities, above or below responding to the maxim without the useful effec materially from that n 4. That they may work to two yards deep und without the proportion w useful effect bears to force being sensibly di 5. In consequence of the ceding property, they util times the greatest possibl tion of power, as they placed below the lowest which the water surfac 6. That they may receive riable quantities of water the relation of the useful the force expended bein rially lessened.

The practical value of t chines is most obvious w are applied to small falls Smeaton's experiments pr with a high fall in which shot water-wheel can b duced, 80 per cent. of the moving power may be And there is little doubt ing to Rühlman, whose tr turbines has been so we lated and edited by Si Kane, that where an wheel, or a wheel with high breasts and overfall can be erected, they are t ferred to the turbine, exc is much back-water to against, when the turbine sunk to a considerable the back-water without

rial loss of its power. Even in cases which admit the working of overshot wheels, the peculiar applicability of the turbine, which affords a direct horizontal motion to the working of corn-mills, should command full consideration before it is relinquished in favour of the overshot wheel. In every case of fall, either higher than that suitable for an overshot wheel, or lower than that required for such a breast-wheel as just described, the turbine decidedly deserves the preference. Smeaton proved that undershot wheels realized only 30 per cent. of the original force.

In falls of great height, the velocity of the machine is so rapid that it may be applied to spinning machinery without mill-work, or with very little, to produce the required speed. The turbine in its present form is of comparatively modern date; the experiments of M. Fourneyron, which resulted in its invention, having been commenced in 1823, and the first machine was erected in 1827. In tracing this form of water-moter to its elements, however, the contrivance which is known as Dr. Barker's mill, must necessarily be noticed. This machine, which is of very old date, consists of an upright pipe or tube, which revolves on a vertical axis, and is formed with an open funnel-shaped top, and closed at the bottom, from which project two horizontal hollow arms or pipes. These arms are closed at their outer ends, but have each a round hole near the extremity, and so placed that the two holes are opposite to each other. The upright pipe is kept filled with water, which flows into the funnel-shaped top. The issuing of the water from the holes on opposite sides of the horizontal arms causes the machine to revolve rapidly on its axis, with a velocity nearly equal to that of the effluent water, the force being in proportion to the hydrostatic pressure which is exerted by the vertical column, and to the area of the apertures; there being no solid surface at the hole on which the lateral pressure can exert itself while it is acting with its full force on the opposite side of the arm. This unbalanced pressure is, according to Dr. Robison, equal to the weights of a column having the orifice for its base, and twice the depth under the surface of the water in the trunk for its height. If the orifice were closed, the pressure upon it would equal the weights of a column reaching to the surface; but when open, the water issues with a velocity nearly equal to that acquired by falling from the surface, and the quantity of motion which is produced is that of a column of *twice* this length moving with this velocity. The revolution of the machine causes the water, which having descended the vertical pipe moves along the arms, to partake of the circular motion, thus producing a centrifugal force that is exerted against the ends of the arms of the machine. According to the laws of motion, this force increases in proportion to the square of the distance from the centre at which it is developed. Thus the velocity of the efflux is increased, and also the velocity of revolution. But as the circular motion has to be imparted to every particle of water as it enters the horizontal arm, which is done at the expense of the motion already acquired by the arm, there is a limit to the velocity even of an unloaded machine. Barker's mill has been treated of by Desaguliers, Euler, John Bernouilli, and M. Mathon de la Cour, the latter of whom proposed, in 1775, to bring down a large pipe from an elevated reservoir, to bend the lower part of it upwards and attach to it a short pipe with two arms, like Barker's

mill reversed, and revolving in like manner upon a vertical spindle; the joint of the two pipes being contrived so as to admit of a free circular motion without much loss of water. By this arrangement a fall of any extended depth may be made available. An improved form of Barker's mill was patented subsequently by Mr. Whitelaw, in which the modifications suggested by M. M. de la Cour were partly included, and a peculiar form given to the horizontal arms, adapted to preserve the centrifugal force from loss or counteraction.

In this mill the two arms form the letter S, the water being emitted from their extremities in the direction of the circle traced by their revolution, the sectional capacity of the arms increasing as they approach the centre of rotation, so as to contain a quantity of water, at each section of the arm, inversely proportional to its velocity at that section.

With a well-made model of this mill, the patentee obtained an effect equal to 73·6 per cent. of the power employed, and nearly equal results are said to have been realized in actual practice. The following particulars of the height of fall and useful effect produced with turbines, already erected on the Continent, will tend to show their increasing value in proportion to the heights of the acting column of water.

Heights of fall in feet.	Useful effect per cent. of power employed.
7·	71·
63	75
79	87
126	81
144	80

In 1837 a turbine water-wheel was erected by M. Fourneyron, an account of which is here quoted from Mr. Joseph Glynn's Report to the British As for the Advancement of Sc 1847. This turbine is ' at St. Blasier, or Blaise, Black Forest of Baden, fc or column of water of (22 mètres). The wheel of cast-iron with wroug buckets; it is about 20 i diameter, and weighs about it is said to be equal to 56 power, and to give an usef equal to 70 or 75 per cen water-power employed. I a spinning-mill belonging d'Eichtal. A second turl the same establishment, is by a column of water mètres, or 354 feet high, v brought into the machine l iron pipes of 18 inches dian the local measure, or ab inches English. The diam the water-wheel is 14¼, o 13 inches English, and it to expend a cubic foot o per second: probably the diture may be somewhat mo this. The width of the wheel across the face is ·2 less than a quarter of an in makes from 2200 to 2300 tions per minute; and on t of the spindle, or upright s the turbine, is a bevelled pi nineteen teeth, working in wheels on the right and le of which has 300 teeth: the motion to the machinery of tory, and drive 8000 water-s roving-frames, carding-e cleansers, and other accessori useful effect is reported to l 80 to 85 per cent. of th retical water-power. The filtered at the reservoir b enters the conduit-pipes; a important to notice this, si apertures of discharge in the wheel are so small as to b obstructed or choked."

Turbith or *Turpith mineral*, (yellow,) is subsulphate of w of a beautiful lemon yello

but so liable to change by the action of light or impure air, that, notwithstanding it has been sometimes employed, it cannot be used safely, and hardly deserves attention as a pigment

Turf is generally found in bogs, in horizontal layers from 10 to 30 feet in thickness; sometimes in the form of a blackish-brown mud; sometimes it is a dark peaty mass, and often a combination of roots and stalks of plants: frequently the turf layers interchange with layers of sand or clay. Sea-water is better adapted to the formation of turf than rain or spring water.

Turf is simply dug with spades, and then dried. If too moist, the semi-fluid mass is piled upon a dry spot, and there left until the water leaks off, and until the mass appears dry enough to be formed into square lumps in the form of bricks. In many instances, however, the freshly dug turf is triturated under revolving edge-wheels, faced with iron plates perforated all over their surface: through the apertures in these plates the turf is pressed till it becomes a kind of pap, which is put into a hydraulic press, and squeezed until it loses the greater part of its moisture: it is then dried and charred in suitable ovens. The charcoal made in this way deserves the notice of the artisan.

The component parts of turf differ from those of wood. This difference is owing to the fact of its being decomposed woody fibre. The following is an analysis of several specimens:

One hundred parts of good turf contained, besides ashes,

	Carbon.	Hydrogen.	Oxygen.
I.	57·03	5·66	31·76
II.	58·09	6·93	31·37
III.	57·79	6·11	30·77

The charring of turf is far more easily effected than the charring of wood, partly on account of its square form, partly on account of its chemical composition. In pits, the charring of turf is not difficult, if the same method is pursued as that adopted in the charring of wood; but channels or draft-holes must be left in the kiln, because the square pieces pack so closely, that, without this precaution, sufficient draught would not be left to conduct the fire. Turf is generally found in considerable masses in one spot; therefore the erection of char-ovens is no object of mere speculation, but affords all the advantages of a permanent establishment.

Turnbull's blue (*ferricyanide of iron.*) Professor Graham's account of this variety of Prussian blue is nearly as follows: It is formed by adding ferricyanide of potassium (red prussiate of potash) to a protosalt of iron: it results from the substitution of three equivalents of iron for three equivalents of potassium. The same blue precipitate may be obtained by adding to a protosalt of iron a mixture of yellow prussiate of potash, chloride of soda, and hydrochloric acid. The tint of this blue is lighter and more delicate than that of Prussian blue. It is occasionally used by the calico-printer, who mixes it with perchloride of tin, and prints the mixture, which is in a great measure soluble, upon Turkey red cloth, raising the blue colour afterwards by passing the cloth through a solution of chloride of lime, containing an excess of lime. The chief object of this operation is to discharge the red and produce white patterns, where tartaric acid is printed upon the cloth; but it has also the effect incidentally of precipitating the blue pigment and peroxide of tin together on the cloth, by neutralizing the chlorine of the perchloride of tin. This blue is believed to resist the action of alkalis longer than ordinary Prussian blue.

Turner's yellow, Cassel yellow, Patent yellow. This is an oxychloride of lead, which may be prepared by different processes: when litharge or the protoxide of lead is acted upon by a solution of common salt, there are formed, soda, which remains dissolved, and a white compound, which is hydrated oxychloride of lead; and this, when heated, loses water, becomes of a yellow colour, and is the compound required. It is composed nearly of one part of chloride and nine parts of oxide of lead: it may also be obtained by heating chloride and oxide of lead together in the requisite proportions, or by heating a mixture of one part of hydrochlorate of ammonia with ten parts of protoxide of lead. In fusing these compounds it is requisite to be extremely careful to avoid any admixture of carbonaceous or combustible matter, as that would reduce a portion of the oxide of lead to its metallic state, which would injure the colour of the product.

Turning tools. These are of two classes, viz. hand-tools and tools fixed in the slide-rest. Of the former, the principal are the heel-tool, graver, planisher, gouge, and chisel: there are many others which, however, are but modifications of these, and are required only in particular cases.

The slide-rest tools are distinguished by the same names as the hand-tools, but vary from them slightly in the forms of their cutting parts, which in the hand-tools are in general rather broader, in order that the part to be cut away may be acted on as long as possible before shifting the tool; for forward motion is in their case continuous only for the short period while the cutting edge can be brought to bear on the material without shifting forward the resting point of the tool. The face or front edge of the tool should in every case be nearly perpendicular zontal diameter of th a small difference is clearance.

The angle of the should be more or le cording to the nature rial to be turned; in softer and more unifor rial, the more acute s angle: for wood, it sh acute, and for iron a acute. The velocity the work is made to r also be adapted to t and must be such that take the greatest effe with the preservation c edge.

The hardening and t turning tools require rience on the part of t for although they ma best possible shape, th than useless unless pr ened. The general hardening and tempe as follows: The cuttin tool is slowly heated i and when of a light cooled quickly in wate very hard and brittle, tempering or reducing per degree of hardne this, it is necessary to part, so that a chan may be readily observ place it upon a red-ho it has become heated degree by contact, the will have a pale straw gradually deepens, and arrived at the requis tint, the tool is remov cooled, after which use. (See also the ar

Turnsole, a kind of co painting

Turn-table, a circular cross-rails fixed on its ported by rollers, an being turned on a c used for moving a ra from one line of ra

Turret, a small tower attached to and forming part of another tower, or placed at the angles of a church or public building, especially in the style of Tudor architecture

Tuscan Style of Architecture. This originated in the north of Italy, on the first revival of the arts in the free cities, and beyond which it has never yet travelled, except in some examples which were introduced by Inigo Jones in the first church of St. Paul, Covent Garden, and by Sir Christopher Wren in porticoes at St. Paul's cathedral, London. This style is characteristic of the people who practise it. The Tuscan, it has been said, should peculiarly be adopted in England.

Tuyères. Before puddling became so generally introduced, the shape and position of the tuyère at a blast-furnace received considerable attention, but since the quality of pig iron has been sought for with but little anxiety, these have ceased to be considered of much importance. The chief purpose of the metallic tuyère is the preservation of the fire-proof hearthstones; the direction and form of the blast are of minor importance. This protection is accomplished, in some measure, by making a coating of fire-clay in the tuyère-hole which is cut in the hearthstones. By this means, constant attendance, and repeated renewal with clay, the tuyère may be maintained narrow: whether formed of clay or metal, it should never be wider than the nozzle. Where one of the former kind exceeds the width of the nozzle, it burns away, and the earth is exposed to destruction. The preservation of the original dimensions of the hearth is the main object which the manager of a furnace seeks to secure; and as the clay tuyère does not effect this object, those made of copper or cast iron have been substituted in its place. These reach further into the furnace than those of clay, and therefore, as it is decidedly of advantage that the blast should be driven as far as possible into the centre of the hearth, the former are much preferable to the latter. If formed of wrought iron, they are liable to burn, as the iron, in consequence of its purity, oxidizes, and forms with the clay around it a very fusible silicate, which is precipitated into the furnace. Gray is preferable to white cast iron, and also to wrought iron; the carbon and impurities it contains protect it against oxidation and destruction. Copper is the best metal for tuyères; it is a good conductor of heat, and is kept cool by the blast more easily than iron. Its silicates also are infusible. If copper oxidizes, and forms a silicate, the latter will protect it. The advantages derived from the copper tuyère have, in Europe, been acknowledged for more than a century; still the charcoal furnaces in America, at which cold blast is employed, are generally blown by clay tuyères, the result of which is the waste of much coal, and the production of inferior iron. This is mentioned as one of those rare cases in which Americans do not make the best use of the means at their disposal. The copper tuyère is protected against the heat of the furnace by the cold blast, which touches it, and for this reason should not be wider than the nozzle. In this point of view, it may be regarded merely as a prolongation of the nozzle, and is, of course, governed by the rules applicable to the latter. So long as pig iron is to be made by the charcoal forge, the desire to make white plate iron in the blast-furnace will exist. It is very difficult, almost impossible, to keep a blast-furnace constantly running upon a certain kind of iron; and therefore the difference which the quality of that in the furnace exhibits is modified to a more or less general standard by means of the position of the tuyère.

such as its direction and inclination. Very skilful management is required, in many instances, to produce the desired effect. In some parts of Europe, where cold-blast iron for the forge is manufactured, the copper tuyère is yet in use; but where pig iron for puddling is made, or hot blast employed, such close attention is not necessary. In America, the niceties involved in adjusting the tuyère can scarcely be appreciated, not even at the forge fires; but this adjustment is unaccompanied with any practical convenience, as the trouble it requires is never compensated. The advantages which arise from a scrupulous attention are, at best, very small; and such attention would, under the conditions which exist in America, especially the high price of labour, result in loss instead of gain.

At cold-blast furnaces, in America, clay or cast iron tuyères, principally the former, are consequently generally employed. Water tuyères are in use at forges, fineries, hot-blast, and at some cold-blast furnaces. A common one for the Catalan forge, the charcoal forge, finery, and charcoal blast-furnaces, is made of boiler plate. The top part is hollow, while the bottom part, which is generally flat, is solid. A water-pipe, of ½-inch bore, conducts a current of cold water through the hollow top: this preserves the tuyère, and protects it against burning. The bottom is made flat, so as to serve as a support to the nozzle; and thus the latter may be readily moved to those places where it is most needed. At blast-furnaces and fineries, this precaution is not of much use, as the nozzle remains at the place where it is fixed; but at forges it must be moveable. Both of the water-pipes are, in most cases, at the top; but this arrangement can scarcely be considered so advantageous as though one pipe, or the entrance of the water, were near the bottom, and the other pipe, or the outflow, at the top.

Tuyères for anthracite, coke, and most of the charcoal furnaces, are perfectly round, and made of boiler plate; seldom of copper or cast iron. The tapering of them does not affect the furnace; and for all the evil this tapering occasions, it may be a perfect cylinder. In using hot blast, it makes no difference how the air is conducted into the furnace, provided the tuyère is kept open, and bright; which is all that is necessary. The nozzle is laid into the tuyère,—how far it reaches into it, is a matter of no consequence,—and the space between them filled up with clay. At a cold-blast furnace, it requires some attention not to push the nozzle too far in, or to draw it too far back. The water-pipes are of lead, ¾-inch, seldom 1-inch bore: one on the lower, and the other on the top part of the brim. The lower pipe conducts the water to the tuyère, and the upper one from it. The former is, in many cases, pushed as far as possible into the interior, to bring the cold water into the furnace; and, the water is thus applied where the heat is greatest. A constant, uninterrupted supply is necessary to prevent the melting of the tuyère. The water must be pure; else it will leave a sediment in it which is sure to cause its destruction. There must also, be a sufficient supply of cold water: if the formation of steam is going on in the interior of the tuyère, the latter is sure to be burned. Copper and brass last longer than iron; but if iron tuyères are well made, and soldered with copper, and if there is no lack of water, they may last a long time. Where there is a deficiency of water, or where there are sediments in the interior of the tuyère, a few hours' heat will destroy it. If it be found that the

do not wear well, attention must be directed to the water; and if nothing appears wrong, the application of larger pipes, or higher hydrostatic pressure, will then remedy the evil. Water tuyères are generally from 10 to 20 inches long; those that are too short are liable to be burnt, by the fire working around them, because there is not sufficient room to keep it closed up. Another disadvantage is, that their want of length prevents them from being pushed into the hearth; but length is necessary when the earth is burned out, and when the blast should be carried further into the interior. The external size is also a matter which requires attention in the construction. The total surface determines the amount of water which is necessary. The larger the surface, particularly the diameter, the greater the amount of water necessary, and of course the greater the danger of burning. A tuyère is seldom more than four inches in diameter inside; but the diameter outside is sometimes twelve, and even more inches. With such an increase of the diameter, however, the danger is augmented.

Tuyères may be considered a prolongation of the nozzle or the blast-pipe, and disconnected from it merely for the sake of preservation, and of more convenient access to the interior of the furnace. Those for cold blast should taper more than those for hot blast, because the former clinker in a greater degree, and require cleaning more frequently than the latter. The more acute the angle of the tuyère, the colder it works; and the more tapered it is, the hotter it works. These observations are of practical importance. In most cases the blast is required as far in the interior of the furnace as possible, because fuel is thus saved, better iron produced, and the hearth protected. There is some difficulty in giving cold-blast tuyères a slight taper, because they should be very wide outside; but this difficulty can be overcome by making their interiors more curved. If the extreme end, as far back as the diameter of the mouth, is cylindrical, the same purpose is accomplished as though the whole were cylindrical. If too much tapered, which is shown by its working too hot, the evil is diminished, in some measure, by pushing the nozzle further into the furnace. This is but a temporary, not a radical remedy; and a tuyère of a proper form must be substituted. If it works too cold, that is, sets on too much cold cinder, the only resource is scrupulously to keep it clean, and to replace it as soon as possible by one more tapered, or with a more obtuse cone. From these considerations, it is evident that different kinds of ore require a tuyère of different taper; but for the exact degree of this taper no general rule can be given. Experience must, in this instance, be the only guide. This will appear more evident on taking into consideration the kind of fuel and the pressure of the blast required. Calcareous ore, as well as the pig iron made from it, works naturally hot at the tuyère; consequently, those more acute are employed, and serve to drive the blast far into the furnace, by which means they are kept cool. This result can be effected by a water tuyère. Clay ores, which work naturally cold, work better with one that is tapered. These considerations, which have a special bearing upon the working of furnaces and forges, are entirely of a practical nature; and for this reason the management of the furnace or forge is accompanied with such different results. It is evident that the modification of a tuyère cannot, at times, be so quickly accomplished as may be desired: months, and even years, are often consumed, before the required form can be

accurately determined; in many cases, this form is never arrived at. The shape is therefore a matter which, at blast-furnaces, generally depends on the decision of the keeper or founder; and as those formed of clay may be altered very conveniently, this may be assigned as one of the reasons why so many of that kind are in use. The whole matter, however, is divested of its mystery when it is found that an obtuse tuyère tends to work warm, while one more acute produces an opposite effect, and is more advantageous as respects both the quality and quantity of work; but it is more difficult to manage. The form of the nozzle, as well as that of a metal tuyère, is permanent; and as the advantage of either shape can be arrived at, in a more or less perfect manner, by pushing in or drawing back the nozzle, no solid objection exists against those formed of metal. Some difference should be made between the form of the nozzle and that of the tuyère. An obtuse nozzle should work with the latter more acute; a slightly tapered nozzle, with one greatly tapered. The latter form is generally preferred, on account of the facility of cleaning.

In applying hot blast, the form of the tuyère and the nozzle is a matter of indifference; but in their construction it is found desirable to adopt the rules here suggested. The advantages of hot blast are sometimes doubtful; and it is therefore better to unite, by means of perfect forms of apparatus, all the advantages derivable from the cold blast, and thus to regain what is lost in quantity by its employment.

In forge fires there are generally but one tuyère and two nozzles. At refinery fires the tuyères are often all on one side; at other places on opposite sides. All these differences are the result of local causes, originating in the form of the apparatus, the qual iron and fuel, the pres blast, and the qualifica workmen. Their numbe position in the blast-f serve attention. In blast, few should be em in using hot blast as m sible. Cold-blast tuyère rally troublesome; they become black, and requi attention, as well in n nozzle as in patching clay; they also tend t white iron, and they coc parts of the hearth. reasons their number reduced as much as p the hot-blast tuyère worl occasions but little troub inclined to produce gra tends to reduce silex, quently to produce a p of iron. Therefore, the many hot-blast tuyeres conveniently employed mended. The position is most favourable when both sides of the hearth. is that part of the heart first burnt out; and if is in the back part of t the distance from it t posite timp is unnece creased.

Tying, in mining, the term ing ores

Tympan of an arch, a trian or table in the corners an arch, usually hollowe riched with branches olive, oak, &c., and some emblematical figures

Tympanum, the triangula the fastigium of any buil prehended between its that of the entablature: of a framed door were *pana* by the Romans

Typhoon is a name frequen to a tropical storm: it is to the hot winds which ally blow with great Africa, Syria, Arabia

hich are felt, though rarely ith much-diminished force, southern parts of Italy and The sirocco of Egypt and asts of the Mediterranean, ıoom of Arabia, and the har- ı of the coast of Guinea, are tood to be so many designations of the typhoon; all of them being supposed to originate in the same cause, with modifications depending merely on the nature of the particles exhaled from the ground in the different countries. They are also said to cause water-spouts at sea.

ULT

ARINE, *Lazuline*, or *Azure*, is ed from the *lapis lazuli*, a ıs stone found principally in and Siberia. It is the most ıted of all modern pigments, om its name and attributes, ably the same as the no less ıted Armenian blue, or *cy-* f the ancients. Of the lat- eophrastus informs us that nour of inventing its factiti- eparation (by perhaps a very r chemico-mechanical pro- ll used for ultramarine) was d in the Egyptian annals to their kings; and it was so prized, that the Phœnicians ıeir tribute in it, and it was n presents to princes: hence a common practice, in those to counterfeit it.

ine ashes (mineral gray) are sidue of *lapis lazuli* from ultramarine has been ex- l, and vary in colour from ay to blue. Although not in beauty, and inferior in h of colour, to ultramarine, e extremely useful pigments, ng grays much more pure ıder than such as are com- of black and white, or other and better suited to the tints of flesh, foliage, the f skies, the shadows of dra- &c., in which the old masters ont to employ them. Ul- ine broken with black and &c., produces the same ef- nd is thus sometimes car- *roughout the colouring of a* *The brighter sorts of ul-*

UNI

tramarine ashes are more properly pale ultramarines, and of the class of blue; the inferior are called mineral gray.

Umber, commonly called *Raw Umber*, is a natural ochre, abounding with oxide of manganese, said to have been first obtained from ancient Umbria, now Spoleto, in Italy. It is found also in England, and in most parts of the world; but that which is brought from Cyprus, under the name of Turkish umber, is the best. It is of a brown citrine colour, semi-opaque, has all the properties of good ochre, is perfectly durable both in water and oil, and one of the best drying colours we possess: it injures no other good pigment with which it may be mixed.

Undecagon, a polygon of eleven sides

Undercroft, a subterraneous apartment or crypt

Underlay. When a vein in a mine hides or inclines from a perpendicular line, it is said to underlay

Underlay shaft, a shaft sunk on the course of a lode

Underlayer, in mining, a perpendicular shaft sunk to cut the lode at any required depth

Undershot wheel, in hydraulics, a wheel with a number of flat boards, which receive the impulse of the water conveyed to the lowest part of the wheel by an inclined canal

Uniform motion. The velocity of a moving body is said to be uniform when the body passes over equal spaces in equal times

Union screws or joints, in locomotive

engines, the brass unions for connecting the elastic bore-pipe of the tender to the feed-pipe of the engine; smaller ones also connect the tender steam-pipe with the feed-pipe and with the boiler. The feed-pipe is likewise attached to the lower end of the pump by a large union screw.

Unit of work. The measure of any amount of work is the work done where a pressure of 1 ℔. is exerted through 1 foot, the pressure acting in the direction in which the space is described. If, instead of 1 ℔. being moved through 1 foot, it be moved through 2 feet, it is clear that the work is doubled, or that two units of work have been done. The difference between the aggregate work done upon a machine during any time by those forces which tend to accelerate the motion, and the aggregate work, during the same time, of those which tend to retard the motion, is equal to the aggregate number of units of work accumulated in the moving parts of the machine during that time, if the former aggregate exceed the latter, and lost by them during that time, if the former aggregate fall short of the latter.

In reference to the unit of time, the unit of mechanical power has been assumed to be 1 ℔. raised 1 ft. high, and 1 minute as the unit of time; the unit of work will therefore be represented by 1 ℔. raised 1 foot high in 1 minute. Now, it is assumed that a horse is capable of doing 33,000 such units of work, *i. e.* that he is capable of raising 33,000 ℔s. 1 foot high in a minute, or 1 ℔. 33,000 feet high; and this is called a *horse's power*, and is the unit of work in reference to the unit of time commonly used in this country.

Universal chuck, a circular plate to screw on the mandril of a lathe, and hold a nut or any small piece of metal to be bored: in the plate are two or more radial slots, fitted by the jaws or pieces which project from the face of the chuck, moved by screws towards the centre, and tightened upon the nut

Unmoor, in navigation, to reduce a ship to the state of riding by a single anchor and cable

Unship, to remove any thing out of a ship

Urn, an ancient utensil, used for a variety of purposes; sometimes as the receptacle of lots or for votes at the public election of magistrates; but its greatest and most frequent use was as a receptacle for the ashes of the dead after their bodies were burnt. These urns were sometimes kept in houses, and also put under tombstones, or within vaults or graves. Urns and similar vessels have been found in the burial-places of the ancient Britons. In modern times, the urn is an utensil of domestic use.

VAC VAL

VACUUM, a vacuity or space unoccupied by matter; in pneumatics, the vacuum caused by an air-pump, which is a degree of rarefaction sufficient to suspend the ordinary effects of the atmosphere.

Vacuum-pump, a pump connected to the boiler of a marine engine, for charging the boiler with water from the sea by discharging the air, causing the water to rise within the boiler, from the pressure of the atmosphere without: by this means much labour and time are saved, which would otherwise be expended in lifting the vats

Vair, a term in heraldry, being a fur composed of four distinct colours; argent, gules, or, and sable

Valve, in hydraulics, &c., a lid con-

trived to open one way, to admit a fluid into a tube, but which shuts when pressed from the other, to prevent its return. In anatomy, a kind of membrane which opens in certain vessels to admit the blood, and shuts to prevent its regress.

Valves, in blast machines, are essential in blast-conducting pipes; first, for shutting up the blast entirely; secondly, for diminishing and increasing it at pleasure. The first kind is needed where the blast is generated, for various purposes, by the same blast machine. The valves in use are, the sliding, the conical, and the trundle. The two first named are but little employed. If well made, the latter kind of valve is very useful. At one end it has a handle, and, in many instances, a graded scale, which indicates the amount of air which passes through the valve, or, in other words, it shows the opening of the valve. At each tuyère or nozzle a valve is required, which serves either to shut off the blast entirely, or to regulate the passage of whatever amount is needed. At the nozzle-valve, a scale is very useful, partly for the purpose of adjusting the blast, and partly for that of fastening the handle of the valve, and keeping it in a certain position.

The laws which govern the construction of blast-pipes, valves, and tuyères, are summarily as follows: The interior of the blast conductors should be as smooth as possible, as an uneven surface causes great friction. The friction of the air is proportional to the length of the pipe, and to the density of the air which passes through it. It is proportional to the square of the speed of the air, and the reverse of the square of the diameter of the pipe. Obstructions caused by short bends in such pipes are inversely proportional to the angle of the bend, and are governed by the laws of hydrostatics. Sudden contractions and expansions of the pipe occasion a whirling disturbance in the current of the air — a loss of power, or, what is the same, of blast.

Valve, the safety, in pneumatics, a valve in a steam engine, to obviate the danger of explosion, by allowing the steam to escape when the pressure is raised beyond a certain weight

Valve-seat, the flat or conical surface upon which a valve rests

Vandyke Brown, a pigment hardly less celebrated than the great painter whose name it bears, is a species of peat or bog-earth, of a fine deep semi-transparent brown colour. The pigment so much esteemed and used by Vandyke is said to have been brought from Cassel; and this seems to be justified by a comparison of Cassel earth with the browns of his pictures. The Vandyke browns in use at present, appear to be terrene pigments of a similar kind, purified by grinding and washing over: they vary sometimes in hue, and in degrees of drying in oil, which they in general do tardily, owing to their bituminous nature, but are good browns of powerful body, and are durable both in water and oil.

Vane, or *Wind-vane*, in navigation, a thin slip of bunting; a string of feathers, &c., stuck up to windward, to show the direction of the wind

Vanes. In Europe, the custom of placing vanes on church steeples is very old; and, as they were made in the figure of a cock, they have been thence denominated weather-cocks.

Vanning, removing the impurities from tin ore

Vaporization. The presence of moisture in the air is accounted for by a modification of the process of vaporization. Water evaporates, or is converted into steam (by steam we here mean the elastic vapour of water, which is always invisible;

what is commonly called steam, but properly cloud, is liquid water in a finely divided or powdered state, wafted like dust by currents of air or of steam, properly so called,) at all temperatures, until the whole space above it, whether containing air or not, is pervaded with watery vapour of a certain fixed density and elasticity, depending on the temperature, and connected therewith by certain laws. The elasticity or expansive tendency of a fluid is estimated by the number of pounds or ounces with which it presses on each square inch of surface that it touches; or by the number of inches of mercury that it will support, as on a barometer.

Steam can exist at any given temperature, and of such density as to have a certain fixed pressure, and no more; and (if there be water enough present) steam will be accumulated till it has this density; but no more can then be accumulated without raising the temperature: and if the temperature be lowered, a portion of the steam will immediately become water, so that (occupying in this state some thousands of times less space than before) it may leave room for the remaining vapour to expand, till its expansive force is reduced to that which the new temperature can support. The pressure of steam is, therefore, always the same at the same temperature. At 212° its elastic force is equal to that of the atmosphere, and it will support a column of mercury 30 inches high, which is the reason that boiling requires this temperature in the open air, when the barometer is at 30 inches; but rather less or more, when the barometer stands lower or higher. Above this temperature it becomes high-pressure steam, which at 220° will support nearly 35 inches of mercury; at 230°, nearly 42 inches, and so on. But the steam which is thrown off from the waters of the earth, from damp soil, from the foliage of plants, and even from ice and snow, has but a very small pressure. Steam at 32° will support only 0·200 of an inch of mercury: at 40°, 0·263 of an inch; at 50°, 0·375 of an inch; at 60°, 0·524, or rather more than half an inch of mercury; at 80°, it will support one inch, and so on. When the air contains as much vapour as can exist at the existing temperature, it is said to be saturated. If in this state it experience the smallest reduction of temperature, some of the vapour must immediately become liquid, assuming the form of cloud, fog, or rain. These effects depend on the cooling of the air below the temperature necessary to retain all its vapour. But when a solid body is cooled below this temperature, (the air remaining above it,) a different kind of deposition occurs, called dew, which does not fall in drops from the air, but grows, as it were, on the solid. Dr. Wells proved, by a most complete investigation of this subject, that instead of dew cooling bodies, as commonly supposed, it is their cooling which causes dew; and its formation even mitigates the cold, by the heat previously latent, which the steam gives out on condensing into water. The degree of heat at which dew begins to be formed is called the dew-point, and instruments called hygrometers have been invented to measure it. The difference between the temperature of the dew-point and the temperature of the atmosphere indicates the degree of dryness, which in this country seldom reaches 30°; that is, the temperature of the earth necessary to condense the vapour of the air is seldom 30° below the temperature of the air. In India it has been known to be 61° below it, and in Africa probably lower still.

If, while dew is forming, the earth continues to cool down until

it reaches the freezing-point, hoar-frost is formed. The beautiful figures seen in winter on the inner surface of window panes, cooled by the external air, are produced by these cold surfaces condensing the moisture of the warmer air within.

Varry, a term in heraldry, denoting the mixture of argent and azure together

Varry cuppy, a term applied to a fur of cups

Vat, a wooden tub, used to wash ores and mineral substances in; a working-tub of any kind

Vault, in architecture, an arched roof, so contrived as that the several stones by their disposition shall support each other

Veering, or *Wearing*, in navigation, the operation to which a ship, in changing her course from one board to the other, turns her stern to windward, in opposition to tacking, wherein the bow is turned to the wind and the stern to leeward

Vein, a course of metal in a mine: a rake vein is perpendicular, or nearly so; a pipe vein, nearly horizontal

Vein, in mining, to wash or cleanse a small portion of ore in a shoal

Velocimeter, an apparatus for measuring the rate of speed of machinery. When the velocity is uniform, the instrument is merely a measurer of distance; but this is not the case with a variable velocity, which requires a much more elaborate contrivance for its estimation. Such a velocity-measurer was constructed by Breguet, of Paris, under the direction of M. Morin, the principle of which may be briefly explained as follows: A circular disc, covered with card or paper, is made to revolve with an *uniform* motion by means of clock-work, regulated by air-vanes: upon this disc, a revolving pencil, whose motion is caused by and corresponds with that of the body whose *variable* velocity is to be measured, describes a curved line; and from this curve, which results from a combination of the variable with the uniform motion, the velocity may be easily ascertained by processes and formulæ adapted to the purpose. One of these cards, with the curve traced on it by the piston of the Cornish steam engine at Old Ford, is engraved in the 'Transactions of the British Association for the Advancement of Science.' This beautiful and ingenious contrivance, by which spaces described in the ten-thousandth part of a second may be easily discerned, is the invention of M. Poncelet, and was carried into execution by M. Morin.

The instrument, when put in order, was first tried at King's College, London, a variable motion being given by a small carriage made to descend an inclined plane. The correspondence of the velocity shown by the machine with that deduced by the known laws of dynamics, was such as to give great confidence in its accuracy. After a few minor alterations, suggested by frequent trials, it was removed to the East London Water-Works, and attached to the Cornish engine at work there, from which several diagrams were taken; and the velocities calculated from these have been expressed in the form of geometrical curves, whose abscissæ represent the spaces passed over by the piston of the engine, and whose ordinates indicate the corresponding velocities at the different points of the stroke.

Velocipede, a carriage which is capable of being propelled along a road by the muscular power of the rider acting upon treadles and levers which communicate with a cranked wheel axle

Velocity, in dynamics, is the ratio of the quantity of linear extension that has been passed over in a certain portion of time; or it is the ratio of the time that has been

employed in moving along a determinate extension.

When a man ascends vertically, his velocity is reduced to about one-half of his horizontal velocity, indicating that he acts against a double resistance; therefore, when a man ascending a ladder, carries a load, the maximum effect will take place when his ascending velocity is about one-fourth of the velocity he can walk horizontally without a load.

A man of ordinary strength will not be able to walk, unloaded, at a quicker rate than 3½ miles an hour, if this exertion is to be continued for 10 hours every day. Indeed, those who examine the subject with a view to a fair average, will find this to be about the extreme velocity that can be continued, without injury, for any considerable time; therefore a man ought to move with half this velocity to produce a maximum effect; that is, at the rate of 1¾ mile an hour, which is about 2½ feet per second.

But this supposes the whole load to be the useful effect, whereas part of it must consist of the apparatus employed to carry it, or the friction of the intermediate machine, or other circumstances of a like nature. About one-fifth of the velocity may be considered equivalent, at an average, to the force lost in friction, &c., in all cases; in many it will exceed one-fifth. Hence the maximum of useful effect will take place when the velocity is 2 feet per second, or about 11 furlongs an hour, continued for 10 hours each day.

Smeaton is said to have made numerous comparisons, from which he concluded that the mechanical power of a man is equivalent to 3750 lbs. moving at the velocity of one foot per minute; and taking this average to be near the true one, as there is reason to conclude it is, we have

$$\frac{3750}{2 \times 60} = 31{\cdot}25 \text{ lbs.}$$

Therefore, we make the averag chanical power of a man 31·2 moving at the velocity of 2 fe second, when the useful eff the greatest possible; or h cubic foot of water raised tw per second; a very convenien pression for hydrodynamical quiries.

If a man ascend a vertical la according to a preceding re the velocity which correspon the maximum of useful effect be 1 foot per second, and the double that which he carries h zontally; consequently the av of useful effect is 62·5 lbs. n one foot per second.

Bricklayers' labourers in Lo ascend ladders with a load of a 80 lbs. besides the hod; somet at the rate of one foot per sec but more frequently about 9 in per second.

Ascending stairs is more tr to the muscles of the legs t ascending a ladder; and there the useful effect is less, till a son has become accustomed to kind of labour: and it is als be observed that the space m over is increased, unnecess except where the horizontal tance is part of the path over w the load is to be moved.

The force of a horse is, a average, about equal to that o men, according to various mates; and the rate of trave about the same, perhaps n less than that of a man, whe exertion is continued for 8 ho consequently the velocity c sponding to the maximum e will be about 2½ feet per se Whence, the average mecha power of a horse may be estim at 187½ lbs. moving with a vel of 2½ feet per second, or 3 c feet of water raised 2½ feet p cond; the day's work being

Velocity of motion. The following is a list of the velocities of moving bodies, extracted from Peschel's 'Elements of Physics,' &c.

	Feet per second.
Rivers	3–4
A very rapid stream	13
Wind (ordinary)	10
Storm	54
Hurricane	80–120
Sound (through air)	1100
„ (through metal)	12,000
Air into a vacuum	1280
Ball from air-gun (air condensed 100 times)	697
Musket-ball	1280
Rifle-ball (at most)	1600
Cannon-ball (24-pounder)	2450
Earth's rotation (at equator)	1525
„ centre (in its orbit)	101,061
	Miles per hour.
Race-horse	60
Pigeon	20–30
Peregrine falcon	120
Ocean steamers	12
River steamers	22
Railway train	80
Sailing vessel	10
Malay proa	20
	Miles per second.
Light	200,000
Electricity	576,000

Velvet painting is the art of colouring on velvet with transparent liquid and other ready diluted colours, compounded and made up with various acids, alkalies, &c., according to their nature and qualities

Venetian Red or *Scarlet Ochre.* True Venetian red is said to be a native ochre, but the colours sold under this name are prepared artificially from sulphate of iron, or its residuum in the manufacturing of acids. They are all of redder and deeper hues than light red, are very permanent, and have all the properties of good ochres. Prussian red, English red, and rouge de Mars, are other names for the same pigment.

Ventilation and warming of buildings is a twofold purpose that should enter into the constructive design of all edifices intended for the residence or occasional congregation of human beings. The necessity for this purpose arises from the fact that the breathing of air (as one of the functions of animal life) renders it unfit for re-inspiration, the lungs retaining the vital properties and emitting the remainder, which consists of ingredients detrimental to health, and even destructive of life itself. In order to keep an apartment in a healthy and pleasant condition, fresh air should be constantly supplied at a temperature from 60° to 65°, and the vitiated air should be as constantly removed; and all the varied schemes which have been propounded for ventilating buildings have this common purpose of constant supply and removal. The vitiated air, on being emitted from the mouth, has a temperature between 80° and 90°; and as the universal effect of heat, manifested in the increase of temperature of the supply, 60° or 65° to 80° or 90°, is to expand and lighten, the vitiated air has a natural tendency to rise to the upper part of the room. To allow this action to proceed, it is evidently necessary that means for its escape at the top should be provided, and also that fresh air should be introduced at the lower portion of the apartment. The operation would, however, be nullified if the heated air, on emerging from the top of the room into a shaft or chimney intended to conduct it away, were met by a downward current of cold air; and it has therefore been deemed advisable to provide not only such a shaft or chimney, but also some means, by stoves or other apparatus, of artificially heating the air in the shaft, and thus assisting the escape of the foul air. And further, in order to secure the constant accession of fresh air and give sufficient impulse to it to overcome any tendenc

that might be created to oppose its introduction by a retrograde movement of the atmosphere of the building, means have been adopted of forcing this fresh air in with fans or bellows. But these two sets of apparatus have been seldom combined. Those who have adopted the shaft have usually contemned the fan, trusting to the sucking action of the former to draw off all the vitiated air, and concluding that fresh air must enter as rapidly to fill its place; and, on the other hand, the adopters of the fan decry the addition of the heating apparatus in the shaft, and contend that its only effect is to draw down foul air for its own supply, and to impede the upward current created by this fan. This effect should be obviated in a well-acting apparatus, which would then doubtless assist the fan in promoting the continual passage of pure air throughout the building. The objection which has been entertained against the use of the shaft without the fan, or some other adequate forcing apparatus, is well-founded on the well-known elasticity of the atmosphere, by which it is susceptible of rarefaction to a considerable extent. The heated shaft consequently acts as a pump in sucking the warmed air upwards, and if no force is in action from below to drive this air upward by the pressure of fresh air entering the apartments, the atmosphere becomes rarefied to a degree which is both unpleasant and prejudicial to sentient existence. It is therefore essential that the two processes of exhaustion and supply shall proceed simultaneously, and be so regulated that no rarefaction shall be suffered in the air to be breathed. The purpose of warming the air in winter, and of cooling it in summer, that is, more properly, of attemperating it, should be sought, and may be attained conjointly with that of ventilation; and one of the best arrangements yet carried out for these combined objects is presented in the system adopted at the Reform Club House in London. The supplying apparatus there employed consists of a large fan which revolves rapidly in a cylindrical case, and is adapted to throw 11,000 cubic feet of air per minute into a spacious subterranean tunnel under the basement story of the building. This fan is driven by a steam engine of 5-horse power, working expansively. It is placed in a vault in front of the building, and as it burns anthracite coal and cinders from the house fires, is not productive of any nuisance or offensive smoke. The steam of condensation supplies three chests, constructed of cast iron, with the heat requisite for warming the building. Each of these chests is a cube in form, and measures 3 feet externally, and is internally divided into seven parallel cases, each 3 inches wide, and separated by alternate parallel spaces of similar width, for the passage of the air as it is impelled by the fan. By this economical arrangement, which thus makes good use of the steam of condensation, 2 cwt. of fuel is sufficient for working the engine during twelve hours, the engine being besides available for pumping water for the purposes of the establishment, and raising coals to the several apartments on the upper stories. The air in passing through the cells between the steam cases is heated to a genial temperature of from 75° to 85°, and thence enters a chamber of brick-work in the basement, from which it is admitted into several distinct flues, regulated by dialled valves or registers, and thus conducted in any required quantities to the several apartments of the building. A stove is placed in the top story, and is formed as a rectangular chest of cast iron, contracted above

into a round pipe, which discharges the burnt air and smoke into a series of horizontal cast-iron pipes, about 4 inches in diameter, which traverse the room beneath the ceiling and terminate in a brick chimney. One advantage of such an apparatus as is here described would be that of introducing cool air during sultry weather, for which purpose it might be readily adapted.

Ventilator, a machine made to turn with the wind, and placed in a wall or roof, in order to throw a due quantity of fresh air into a close apartment

Verdoy, a term in heraldry, applied when a border is charged with leaves, fruits, and flowers, and like vegetables

Verge, a rod, wand, or sergeant's mace; also the compass about the king's court that bounds the jurisdiction of the lord steward of the king's household, and of the coroner of the king's house, and is accounted 12 miles' compass; also a rod whereby one is admitted tenant, holding it in his hand and swearing fealty to the lord of the manor, and for that cause called tenant by the verge

Verge, a small ornamental shaft in Gothic architecture

Vermiculated, chequered; continuous; embroidered with several colours

Vermile, a cloth or napkin on which the face of Christ is depicted, derived from the incident related of of St. Veronica

Vermillion, a sulphuret of mercury, which, previous to its being levigated, is called cinnabar. It is an ancient pigment, and is found in a native state, and produced artificially. Vermillion probably obtained its name from resemblance to or admixture with the beautiful though fugitive colours obtained from the vermes or insects which yield carmine

Vernier, a graduated moveable index, used for measuring minutely the parts of the space between the equidistant divisions of a graduated scale

Versed sine of an arc, in geometry, the position of the diameter intercepted between the sine and the commencement of the arc

Vert, in heraldry, a green colour; in the ancient forest laws, every thing that grows and bears a green leaf within the forest that may cover and hide a deer

Vestiary, a wardrobe, or place to lay clothes or apparel in

Vestibule, in architecture, the porch or the first entrance of a house

Vestibulum, part of the andronitis of a Greek house, similar, probably, to the prostas of the first peristyle or court

Vestment, a set of hangings for the service of an altar; and also a suit of robes for a priest

Via (Latin), by way of; in the time of the Romans, a road or a right of road. Two shallow trenches were commonly dug parallel to each other, marking the breadth of the proposed road: this in the great lines, such as the via Appia, the via Flaminia, the via Valeria, &c., is found to have been from 13 to 15 feet, on the via Tusculana 11; while those of less importance, from not being great thoroughfares, such as the via which leads up to the temple of Jupiter Latialis, on the summit of the Alban Mount, and which is to the present time singularly perfect, seems to have been 8 feet wide.

Viaduct, a term applied to extended constructions of arches or other artificial works to support a roadway, and thus distinguished from *aqueducts*, which are similar constructions to support water-ways. This term has become much more familiar within the present century, in consequence of the great number of vast structures so designated which have been erected in various parts of Great Britain for the purpose of carrying rail

ways over valleys and districts of low level: but the general name of viaduct is now recognized as applicable to all elevated roadways for which artificial constructions of timber, iron, bricks, or stone-work are established; and accordingly among the principal railway-works are to be enumerated viaducts of all these materials. The vast dimensions of some of these structures are not more striking to the casual observer, than their great strength, as particularly adapted to railway traffic, is apparent upon a careful study of their construction. The several members of a viaduct are the same as those of a bridge; indeed, the former structure may be considered as an extended bridge, frequently resorted to in situations where no water is to be crossed. The necessity which is imperative in the construction of railways for preserving a horizontal level for the roadway, or at least departing from this level within very restricted limits, imposes the raising of the railway surface in many places, and to a considerable extent above the natural level. Various considerations arise as to the preferable mode of effecting this raising, whether by solid embankments of earth-work or by an open or arched structure of other materials. Embankments of earth-work are often liable to subsidence from want of cohesion in the materials, or the effect of long-continued rains; and if free from actual danger arising from these liabilities, they are always sources of much constant expense in making up the surface to the required level, to compensate for the continual depression caused by the passage of heavy loads over them. As a question of economy, therefore, viaducts are often to be preferred, since their repairs involve less expense than those of embankments. It must also be considered that the latter, owing to their necessary extension of base, cover a much wider portion of ground than viaducts, and at the same time cover it in a more absolute and objectionable manner. A solid embankment, like a black line across a picture, spoils a beautiful landscape, and often precludes all view beyond it from sites which otherwise would command an extended range. If the sub-formation of the valley be of a very loose and boggy nature, embankments are scarcely admissible, nor, if the height to be raised exceeds 30 or 40 feet, can they be entertained. Indeed, in the majority of cases, valleys, whether having rivers of magnitude or not, are more economically crossed upon viaducts than embankments.

Whatever the materials of the structure or its finished design, the same points are to be observed in the construction; and the first of these is the strength and durability of the foundations. A substantial and permanent character should always be secured for these, even if the superstructure is intended to aim at cheapness rather than solidity. It is often requisite that the piers and abutments be constructed upon piling,—a form of foundation adapted, if thoroughly executed, to afford the most secure basis; but if done carelessly and insufficiently, liable to involve the most destructive failures. The citation of a few of the most extended works of this class, of modern date, will best show the details of the present approved kinds of construction.

Of timber viaducts, two fine examples of similar construction are presented on the line of the Newcastle, North Shields, and Tynemouth Railway, and erected according to designs by Messrs J. and B. Green, of Newcastle. One of these works, which crosses the Ouse bourn, besides a public roadway, a mill-race, and the adjacent valley, consists of five spans or arches of timber-work, and four end arches

of masonry. Of the former arches, three are 116 feet wide in the clear, and two 114 feet. Two of the end arches are 43 feet span, and the other two 36 feet. The height of the rails above the bed of the bourn is 108 feet. The width of the structure allows 26 feet for a double line of rails, and 5 feet for a footway. The total length of the viaduct is 918 feet, and the two middle piers are erected upon piles, from 21 to 27 feet in length. All the piers are of masonry, and tapered upwards, the principal being 21 feet wide above the footings, and 15 feet at the springing of the arches. The piers are continued upwards, of reduced dimensions, to the level of the roadway, the whole of the five main arches, spandrilling, and superstructure, being formed of timber. The radius of these arches is 68 feet, and their rise or versed sine about 33 feet. The ribs forming the arches are composed of planks of Kyanized Dantzic deal, the lengths of which vary from 20 to 46 feet, by 11 inches wide, and 3 inches thick. These planks are so arranged, that the first course of the rib is two whole deals in width, the next is one whole and two half-deals, the joints being crossed longitudinally, as well as in the depth. The thickness of each rib is made up of fourteen deals, which are bent over a centre to the required form, and fixed together with oak trenails, 1½ inch in diameter, placed 4 feet apart, and each trenail perforating three of the deals. Between the joints a layer of strong brown paper is placed, previously dipped in boiling tar. The spandrils are formed of trussed framing; and the platform of the roadway, which is composed of 3-inch planking, is supported upon transverse beams laid 4 feet apart. The *platform is covered with a composition of boiling tar and lime,* mixed with gravel in applying it, thus forming a coating impervious to water.

There are several other modes of constructing timber viaducts, without introducing the arches, composed of planks curved into proper form, and which, being laid together like leaves, as just described, have obtained for this kind of construction the name of the 'laminated bridge.' In other forms of timber viaducts, the requisite strength is obtained by trussing, the peculiar description and complication of which depends, of course, mainly on the extent of the span or width of each lay of which the entire structure consists. Where a great width of clear opening is required, a system of diagonal bracing offers peculiar advantages, being susceptible of any desired strength and rigidity. A viaduct of great extent, built upon this principle, is on the line of the Richmond and Petersburgh Railway, North America. The length of this structure is 2900 feet, and the trusses are supported upon eighteen granite piers, the distances between which vary from 130 to 153 feet. They are founded on the granite rock, and are 40 feet high above the water. The depth of the truss-frames (which are horizontal on top and bottom) is 20 feet. Another work of the same kind crosses the Susquehannah, and is 2200 feet in length, divided into spans of 220 feet each.

Of viaducts formed of brick-work and masonry, that named the 'Avon Viaduct,' on the line of the North-Western Railway, may be mentioned. This consists of nine semi-elliptical arches, 24 feet in span, and 7 feet 6 inches rise, and three semicircular arches at each end of 10 feet span. This viaduct is entirely faced with stone, the interior of the work being of brick. The end arches have brick inverts between the piers above the found

ations, which are laid uniformly in a solid bed beneath these arches, with steps according to the nature of the substratum. An invert of brick-work is built to the three middle arches, forming an artificial channel for the river, and faced at each end with a row of sheet-piling, driven through the loam into a bed of strong gravel beneath. All the foundations which do not reach the gravel are laid upon beds of concrete, and a layer of the same material covers the extrados of the arches, and forms a level bed for the gravel in which the sleepers of the railway are bedded. Many similar works of much more extended dimensions have been erected for railway communication. One of these, of peculiarly light appearance, is known as the 'Victoria Bridge,' and built over the valley of the river Wear, on the line of the Durham Junction Railway. This work consists of two main arches, one 160 feet span, the other 144 feet, two others, each 100 feet span, and six end arches of 20 feet span. The height of the parapet above the high-water level at spring-tides is 125 feet, and all the arches are semi-circular. The central pier is 23 feet 9 inches in width, and 69 feet high from bottom of footings to springing of arches. The two contiguous piers are 21 feet wide, one 50 feet, the other 52 feet high. The height of the parapet above the springing line of the two main arches is 78 feet. A viaduct, recently constructed over the Moine, at Clisson, near Nantes, in Brittany, is worth notice, for a peculiarity in its construction, which, although not strictly new, is to be found in very few examples. This peculiarity is, that the piers are pierced with a pointed arch, which intersects the cylindrical soffit of the main arches in the direction of the length of the viaduct, so that the roadway is supported upon a groined vault, which, seen from the abutments, has the appearance of the aisle of a Gothic cathedral. This viaduct consists of fifteen arches, and is 348 feet in length. The abutments rest upon a granite foundation, the structure itself being constructed of a fine white granite, and the stones of large size. The foundations are 6 feet below the bed of the river, the height from which to the springing line of the arches being 33 feet, and the total height from the foundation to the top of the parapet 61 feet.

Vibration, the regular reciprocating motion of a body, as a pendulum, musical chord, &c.

Vice, a tool for holding a piece of metal, while operating upon it, by placing it between two jaws or nippers, and screwing them towards each other

Vice-bench, the bench to which a vice is fixed

Villa, among the Romans, a farm or country house

Villa rustica, a tasteful country residence. (See Parker's 'Villa Rustica')

Villa urbana, a residence so called by the Romans, because its interior arrangements corresponded principally with those of a town-house

Villas of the ancients. Varro Columella says, "An estate should be in a wholesome climate and fruitful country; one part champaign, and the other hilly, with easy descents either to the east or south; some of the lands cultivated, others wild and woody; not far from the sea or a navigable river, for the easier exportation of the produce of the farm, and the importation of necessaries. The champaign lying below the house should be disposed into grounds for pasture, tillage, osiers and reeds; some of the hills should be naked and without trees, that they may serve best only for corn, which grows in a soil moderately dry and [illegible]

better than in steep grounds; wherefore the upper corn-fields should have as little declivity as possible, and ought to resemble those in the plain: from thence, the other hills should be laid out into olive-grounds and vineyards, and produce trees necessary to make props for those fruits, and, if occasion should require building, to afford timber and stone, and also pasture for cattle. Moreover, constant rivulets of water should descend from thence upon the meadows, gardens, and osier-grounds, and also serve for the convenience of the cattle that graze in the fields and thickets: but such a situation is not easily to be met with; that which enjoys most of these advantages is certainly most valuable; that which has them in a moderate degree, is not despicable. The natural good qualities of a situation mentioned by Palladio are, a salutary air, plenty of wholesome water, a fruitful soil, and a commodious place: we may hence conclude that those places are healthy that are not located in deep valleys, or subject to thick clouds, where the inhabitants are of a fresh complexion, have clear heads, good sight, quick hearing, and a free distinct speech; for by these things is the goodness of the air distinguished; and the contrary appearance proclaims that climate to be noxious. The unwholesomeness of water may be thus discovered: in the first place, it must not be conveyed from the ditches or fens, or rise from minerals, but be very transparent, not tainted either in taste or smell, without settlement, in winter warm, in summer cold; but because nature often conceals a more lurking mischief, in these outward appearances, we may judge whether water is good by the health of the inhabitants: if their cheeks are clear, their heads sound, and little or no decay in their lungs and breasts; for generally where the distempers in the upper part of the body are transmitted down to the lower, as from the head to the lungs or stomach, there the air is infectious: besides, if the belly, bowels, sides, or veins, are not afflicted with aches or tumours, and there is no ulcer in the bladder; if these or the like are apparently in the major part of the inhabitants, there is no cause to suspect the unwholesomeness of the air and water. The fatal consequences proceeding from bad air, Varro tells us, are in some measure to be alleviated, if not prevented, by the skill of the architect. His words are: That land which is most wholesome is most profitable, because there is a certain crop; whereas, on the contrary, in an unhealthy country, notwithstanding the ground is fertile, yet sickness will not allow the husbandman to reap the fruits of his labour; for where one exposes his life to certain dangers, for uncertain advantages, not only the crop, but the life of the inhabitant, is precarious; wherefore, if it is not wholesome, the tillage is nothing else but the hazard of the owner's life and his family: but this inconvenience is remedied by knowledge, for health, which proceeds from the air and soil, is not in our disposal, but under the guidance of nature; yet, nevertheless, it is much in our power to make that burthen easy by our own care; for, if upon account of the land or water, or some unsavoury smell, which makes an irruption in some part of it, the farm is made unwholesome, or upon account of the climate, or a bad wind that blows, the ground is heated, these inconveniences may be remedied by the skill and expense of the owner, which makes it of the last concernment where the villas are placed, how large they are, and to what quarters their porticoes, gates, and windows are turned. Did not Hippocrates the

physician, in the time of a great plague, preserve not only his own farm, but many towns, by his skill? When Varro and his army and his fleet lay at Corcyra, and every house was filled with sick persons and dead bodies, by his care in making new windows to the north-east, and obstructing the infection by altering the position of the doors, he preserved his companions and family in good health. As a house should be built in a wholesome country, so it should be in the most wholesome part of a country; for an open air, and at the same time infected, causes many distempers."

Villas (*Roman*). The term villa was applied to a cluster of buildings in the country for the accommodation of the family of a wealthy Roman citizen. Very extensive villas were divided into three parts; the Urbana, the Rustica, and the Fructuaria. The first contained the eating-room, bed-chambers, baths, covered porticoes, walks, and terraces. The villa rustica was the division for the servants, stables, &c.; and the fructuaria for wine, oil, and the produce of the farm. Although the Roman villas were the boast and delight of poets and philosophers whose works have fortunately reached us, yet no description has been conveyed of their external architecture. From the magnificent style of public buildings at Rome, moderns were led to suppose that the villa architecture bore some analogy in splendour of outward appearance; but from inspection of their remains, and from the late disinterment of one on the outside of the walls of Pompeii, little doubt now remains on the subject. It is true that the extensive remains of Adrian's villa, and that of Mecænas, covered ground equal almost to a small town, but no regular plan of architectural elevation can be traced with all the ingenuity of even a Roman antiquary. The Pompeian is certainly the most complete example of an ordinary sized Roman villa: situated on a sloping bank, the front entrance opened, as it were, into the first floor, below which, on the garden side, into which the house looks, (for the door is the only aperture on the road side,) was a ground floor, with extensive arcades and open rooms, all facing the garden; and above were the principal rooms. It was spacious, and near the entrance was a bath with all the necessary appendages; in the rear the best rooms opened upon a terrace, running the whole width of the house, and overlooking a garden about 30 yards square, surrounded by a covered walk or portico continued under the terrace. The lower apartments under the areade were paved with mosaic, coved and beautifully painted. One of the rooms had large glazed bow-windows; the glass was thick, of a green colour, and set in lead like a modern casement. The walls and ceilings of the villa were ornamented with paintings of elegant design, all of which had relation to the uses of the respective apartments. In the middle of the garden was a reservoir of water, surrounded by columns. The cellars extended under the whole of the house and the arcades.

Pliny tells us that the size of the villa urbana, and its number of parts, were determined by the pleasure or quality of the master, but those parts belonging to agriculture, by the bulk of the farm and the number of cattle. The servants that in most great men's houses were more immediately for the master's use, and may be said to have belonged to the villa urbana, were the *atrienses*, which included all those we call livery servants, and those belonging to the bed-chamber; and the *topiarii*, which were gardeners belonging to the pleasure-garden; with comedians, musicians, and the notaries or secretaries. The

principal person over the other parts of the villa was the procurator or bailiff; then the *villicus* or husbandman, who had under his care the tillage of the land, and the disposal of the produce of the earth about the villa; next was the *villica* or house-keeper, to whose care every thing within doors belonged, and who had immediately under her command the women servants that were employed in those affairs, but particularly those belonging to the feeding and clothing of the household. The master of the cattle may take the next place, and under his command were all the herdsmen, shepherds, goatherds, swineherds, and grooms. The care of all those fowl that were within the bounds of the villa was committed to the poulterer. In great villas it was thought necessary to keep within the family useful mechanics, as smiths, carpenters, &c. The cattle within the villa were horses and mules, &c.; and to make provision for the several persons and animals, and also for corn and the necessary offices of the house, was the architect's care; and the disposition of each part was governed by rules that may be collected from Cato, Vitruvius, Varro Columella, and Palladius.

Of the Greek villas, no description has been transmitted to us; in villa gardening, however, considerable progress at that time was made, borrowed probably from Asia Minor: myrtles and roses adorned them; the box and lime tree were planted for topary works; and Theophrastus tells us, that flowers and fruits were cultivated in the winter; and the violet more particularly was in profusion in the market of Athens while snow was on the ground.

Villas (*Italian*). The description of an Italian villa built in the time of Michael Angelo, Raphael, Julio *Romano, Dominichino,* Paul Veronese, and Pietro da Cortona, deserves the notice of architects. "The palace of Caprarola is situated on the summit of Mount Camino, near Viterbo: below is the village of the same name, of which the principal street runs in a direct line down the descent from the front of the building, but with a sufficient space between them. A double stair, partly direct, partly curved, with terraced landing-places decorated with balustrades, leads to the palace. Entrances under the terraces of the stairs conduct to the underground parts of the building. The form of the palace is a pentagon flanked by five bastions, surrounded by a sunk area. Hence there is a mixture of civil and military architecture that has a good effect. The palace is built in two orders of architecture; the one, Ionic, with semicircular-headed windows; the upper, Corinthian, comprehending both the first floor and the mezzanine above. Within the pentagonal figure is included a circle, comprehending the court, the porticoes, the offices, and stairs. The decorations of the whole and the parts are executed with much skill. Although the entire edifice is not great, yet the parts are on a great scale, apparently."

Virtuoso, a man skilled in antique or natural curiosities, studious of painting, statuary, or architecture

Vis absoluta, absolute force

Vise, a spiral staircase, the steps of which wind round a perpendicular shaft or pillar, called the newel

Vis inertiæ, the propensity of nature to remain in its actual condition, whether of motion or rest, and to resist change

Vis insita, the power or innate force essentially residing in any body, and by which it endeavours to preserve its present state, whatever that be

Viscount, in law, signifies as much as sheriff: in heraldry, it signifies a degree of nobility next to an earl

Vis viva (work). The vis viva of a body is its mass multiplied by

the square of its velocity: work, or dynamical effect, supposes a body moved, and a resistance overcome; and either of these, without the other, is insufficient to constitute work. The work produced by a pressure moving a body through a certain space is defined to be the product arising from multiplying the pressure by the space through which this pressure acts.

Vitreous, glassy; consisting of or resembling glass

Vitrification, the act of changing into glass

Vitriol, oil of, sulphuric acid

Vitruvian Scroll, a peculiar pattern of scroll-work, consisting of convolved undulations, used in classical architecture

Viz. (*To wit*), that is; a contraction of videlicet

Voider, in heraldry, a gentlewoman's armory, consisting of an arch line, moderately bowing from the corner of the chief toward the nombril or centre of an escutcheon

Voiding, a term in heraldry, signifying exemption of some part of the inward substance of things voidable, by reason whereof the field is transparent through the charge

Volant, in heraldry. When a bird is drawn flying, or having the wings spread out, it is said to be volant.

Volute. The characteristic ornaments and indicial marks of the Ionic capital formed by circumvolving spiral mouldings are termed volutes. The small circle in which the spiral or springs terminate is called the eye of the volute. The introduction of volutes is said by Vitruvius to have arisen from an imitation of the mode in which women were formerly accustomed to ornament their hair; but they are thought, with greater probability, to have represented the horns of the Ammonian Jupiter.

Voussoirs, in architecture, vault-stones, or those that immediately form the arch of a bridge, vault, &c., and are cut somewhat in the shape of a truncated pyramid

Vugh, in mining, a cavity

WAG

Waggons, vehicles for the conveyance of persons, merchandise, &c., varying in form according to their use, and dating in their origin from the remotest antiquity: "Joseph gave them waggons, according to the commandment of Pharaoh, and gave them provision for the way."—*Gen.* xlv. 21.

Waggon-boiler, a low-pressure boiler, having the form of a waggon, with arched top and incurvated sides

Wainscot, a name given to boards employed to line the internal walls of an apartment, so called from foreign species of oak named wainscot being first used for such a purpose. Wainscoting, as it is called, both of Flemish and English oak, was commonly used for interior linings in Tudor, Elizabethan, and Stuart times.

WAL

Waist, in a ship, the uppermost part of the top-side

Wake, in navigation, denotes the print or track of a ship on the surface of the waters. Two distinct objects seen at sea are said to be in the wake of each other when the view of the furthest is interrupted by the nearest.

Wales, in ship-building, are an assemblage of strong planks extending along a ship's side, serving to reinforce the decks and form the curves of the vessel

Wall-plate, a piece of timber placed along the top of a wall, to receive the ends of the roof timbers, or so placed on a wall as to receive the joists of a floor

Walnut wood. The royal or common walnut is a native of Persia and the north of China: it was

formerly much used in England before the introduction of mahogany. The heart wood is of a grayish brown, with black-brown pores, and often much veined with darker shades of the same colour. Some of the handsome veneers are now used for furniture, frames of machines, gun-stocks, &c.

Wardrobe, a place where the garments of kings or great persons used to be kept; and he that keeps the inventory of all things belonging to the king's wardrobe is called Clerk of the King's Wardrobe

Wards and *Liveries*, a certain court erected in the time of Henry VIII.

Warp, in navigation, to change the situation of a ship in harbour, &c., by means of ropes or warps attached to buoys, posts, rings, trees, &c.

Washing, in painting, to lay a colour, such as Indian ink or bistre, over a pencil or crayon drawing, to render it more natural, and add to the shadow of prominences, apertures, &c.

Wassail, a term which is said to have had its origin at the meeting of Vortigern and Rowena, the daughter of Hengist. Geoffrey of Monmouth states, that the lady knelt before the king, and presenting him with a cup of wine said, 'Waes-hæl,' which in Saxon means 'Health be to you.' Vortigern, as he was instructed, replied, 'Drinc-hæl,' *i. e.* 'drink the health:' Rowena drank, upon which Vortigern took the cup and pledged her. Hence the term and custom.

Waste steam-pipe, in steam engines, the pipe leading from the safety-valve to the atmosphere

Waste water-pipe, in steam engines, the pipe for carrying off the surplus water from the hot well

Water is the most abundant and important fluid in nature: it is proved to be composed, by weight, of 8 parts of oxygen and 1 part of hydrogen, and is resolvable into both these gases by voltaic action, and by intensely ignited platinum: other heated metals combine with its oxygen, and liberate the other gas. When hydrogen and oxygen are mixed in the proportion given, and ignited, they unite with explosion, and water alone is produced. The purest water in nature is that which descends from the atmosphere; that of springs, rivers, and the ocean being more or less charged with mineral matter. When the foreign substance is not volatile, the water is easily separable by distillation in the form of a pure vapour or steam, while the fixed substance remains. In nature, the solar heat produces this effect on a vast scale, evaporating enormous quantities of water into the atmosphere, whence, by cooling to various degrees, it falls again in the form of rain, hail, or snow: this, in its passage through different strata towards its lowest level, dissolves any soluble matters which it may encounter, of which salt is the most conspicuous, conveying them ultimately into the ocean. This process, operating for ages, is fully sufficient to account for the prevalence of so soluble a mineral as common salt in sea-water, and the comparative purity of that of rivers.

When water runs through beds of chalk or selenite, it acquires both an acid and alkaline quality in a small degree. The acid is discovered by a few drops of solution of oil of tartar: this alkali will seize the acid, and descend with it in a cloud to the bottom of the glass, where, if permitted to stand a sufficient period, it will concrete into a neutral salt. The alkaline part is discoverable by a few drops of the solution of oxalic acid. This acid has so strong an affinity to calcareous earth, that the smallest quantity in water is detected by it. There are numerous tests which discover acid and alkali in water;

as, the syrup of violets, tincture of turnsole, ash-bark, logwood, &c. Strictly, philosophically speaking, sea-water is not salt, because if a given quantity is put into a glass retort, by sand heat from material fire it will pass over perfectly fresh, and the marine salt it contained will be left behind. Snow and rain waters, when collected at a distance from smoky towns or cities, if collected and kept in a stagnated state, go repeatedly into a state of fermentation, and sometimes become putrid, by the extraneous matters they receive in passing through the lower atmosphere, previous to their reaching the earth. If the specific gravity of water is considered at 1000 ounces the cubic foot, common air will be $1\frac{3}{8}$, fine gold will be $\frac{1}{20000}$, and pure platina $\frac{1}{22000}$; or if a datum is taken of 1 for water, gold will be 20, and refined platinum 22. Water is incompressible, as experiment proves. It has been put into a gold globe, and great power applied in vain to press it into a smaller compass; it passed off by oozing or sweating through the pores of gold. It will rise in some cases above its own level, in a small degree, by capillary attraction. If a piece of dry loaf sugar or sponge is put into a shallow vessel of water, and have part of it unimmerged, the fluid will be seen to ascend above its level. Water will also ascend to the height of 32 or 33 feet above its level in a vacuum, as in pumps, by the pressure of the atmosphere, which varies more or less according to its density, that is, calculating on the pressure of the atmosphere, at the height of 15 miles. The pressure of water on the base of the vessel in which it is contained is as the base and perpendicular altitude, whatever be the figure of the vessel that contains it. A body immersed in water loses as much weight as an equal bulk of the water weighs, and the water gains t weight. Thus, if the b equal density with the loses all its weight, and s no force but the water t it: if it be heavier, its the water will be only t ence between its own w the weight of the same water, and it requires a sustain it just equal to th ence; but if it be light quires a force equal to t difference of weight to kee rising up in the fluid.

Water of great rivers tainly be deemed the m and wholesome for all and domestic concerns, i ent of its superior fertilizin when used for the purpos culture or the growth o and when thrown into r and cleared of its sedime comes clear and equally tra with the brightest water pr from the hardest rock; vious to its being thus d while swiftly gliding wi banks, it deposits large po its bituminous, calcareou laceous, and chalybeate qu

Water is a conductor spheric air, as well as In Ralph Dodd's 'Civil E an accident is mentioned, t one of his workmen was by the falling of 40 feet of the bottom of which app to a sand highly charg water. He remained fro evening till Tuesday morni workmen were this cons time before they came t conversing together and ex over his head, which consi increased his hope of be leased from his horrid ca for he became aware o endeavours for his release as the workmen had ente sandy stratum, through wh water filtered downward,— evidence of its convey

as well as atmospheric air, or, doubtless, he could not have existed.

Day-springs, either lying near the surface of the earth, or finding fresh passages thither, break forth into open air on their own account; while those of a deeper nature are sunk down so low as to require hydraulic machinery to bring them up again. Next, they are called top-springs, inasmuch as they appear either above the rock which severs the soil from the mine, or underneath it. Top-springs differ from deep or other springs, in that they stagnate between the superficies of the earth and the surface of the parts confining them, till they are opened by the miner; and those springs that can be let off by drifts, headings, soughs, and trenches, are distinguished from those of the deep, the draining of which by such means is altogether impracticable or absolutely impossible. In the search after the original source of those currents of water, which, issuing out of the earth, and are commonly called day-springs, the first consideration that arises is, that their natural course, as consisting in motion, is merely local, and caused by the propension of their own weight, still drawing them downward, towards the centre of the earth: their course must always be upon a constant descent from a higher situation to a lower, and so must proceed originally from rain, distilled from the clouds. And if it happen, that at their emersion out of the earth, their spring rises upwards, it is caused by the curvity of their passage, that (syphon-like) points the way; while the preponderance of the water contained in its other arm, descending from a greater height, forces it to rise contrary to its natural inclination.

The specific gravity of rain-water *is 1000; weight of a cubic foot* 62½ lbs.; weight of a column, one inch square and a foot in height, 0·434 lbs.; of an ale gallon 10·2 lbs.: expands $\frac{1}{17}$ of its bulk in freezing, and $\frac{1}{8888}$ for every degree of heat: boils at 212° under the ordinary pressure of the atmosphere: maximum density 39°·38 of Fahr. The specific gravity of sea-water is 11·0271.

Water-colour painting is the art of making a picture with colours ground up with various kinds of aqueous gums or sizes, then called transparent colours. These drawings are executed on various kinds of paper, and are generally termed tinted drawings. The following are the most permanent colours, and therefore most valuable to the water-colour painter: *blues*—ultramarine, French ultramarine, cobalt, indigo, and smalt: *reds*—Indian red, light red, Venetian red, scarlet vermillion, carmine, pink madder, rose madder, purple lake, and red orpiment: *yellows*—cadmium yellow, gamboge, yellow ochre, Indian yellow, mars yellow, lemon yellow, Roman ochre, brown ochre, mars orange, raw sienna, Italian pink, gallstone, and king's yellow: *purples*—purple madder, Indian purple, and burnt carmine: *browns*—burnt sienna, brown pink, burnt umber, Vandyke brown, sepia, mars brown, Cologne earth, bistre, and madder brown: *greens*—emerald green, olive green, and green oxide of chromium: *blacks*—ivory black, blue black, neutral tint, and British ink: *whites*—oxide of zinc or Chinese white, and sulphate of barytes or constant white.

Water-crane, an apparatus for supplying water from an elevated tank to the tender of a locomotive engine

Watering the streets of Paris (*the contract for*). The contractor for this service receives 105,000 francs per annum, or £4200 sterling. It lasts from March 15th to October 15th.

He is bound to hold at the disposal of the engineers who are charged with the direction of the roads, twenty-five carts during the first month of the season; during the second, the number is fixed at fifty-five; during the remainder at ninety, with fifteen others in reserve. These carts can only be used for the service of the town; and they are repainted every year. They contain 1 mètre cube, or 1 ton each, and are drawn by one horse. They have a double discharge hose; at the front and at the back. At half-play they water 1000 mètres superficial. At full play they water 700 mètres superficial. In the first case, they are emptied in 10 minutes; in the second, in 6 minutes. Each cart costs 800 francs, or £32; of which 200 francs, or £8, are for the machinery necessary for the distribution of the water.

The Avenue de Neuilly in the Champs Elysées forms a special service, on account of the immense number of carriages which traverse it. The total surface is 32,000 mètres superficial, or nearly 8 acres English (7·976 a.) The cost per day in the summer months is as follows:

2 water carts, horse and driver included, each at 11·10 f. = . . .	22·20
84·00^{m} cube water (a mètre cube = 1 ton) at 0·137 f. = . . .	11·50
Turncock (portion of his time)	2·00
Total	35·70

or 0·001116 f. per mètre superficial.

It has been found that the streets of Paris require to be watered 135 days on the average; the numbers are between 107 in the wettest season, and 147 in the driest. On the above average of 135, 100 days require a double watering. The quantity consumed is about 1 litre (1·760773 pints English) per mètre superficial; 1¼ litre, when the roads are so very dry as to require a more abundant watering; and 1·60 litre (or 2·82 pints English) in the Avenue de Neuilly. The water columns are spaced so as to avoid any useless movements of the carts; in fact, in such a manner as to allow of their being emptied between one column and the other. The usual distance is 500 mètres (about 550 yards.)

Water-sail, in navigation, a small sail spread occasionally under the lower studding-sail or driving-boom, during a fair wind and smooth sea

Water-spout, a strongly agitated mass of air, which moves over the surface of the earth, and revolves on an axis, of which one extremity is on the earth and the other in a cloud. From this cloud a continuation proceeds downwards, which forms the upper portion of the water-spout; while the lower portion, besides air, consists sometimes of water, sometimes of solid portions, according as the waterspout passes over land or over water. Some have separated water-spouts over the land and over the water from each other; but this creates confusion, for water-spouts have been observed which were formed over water, and advance over land; and *vice versâ* we have accounts of water-spouts which were formed over land, and afterwards suspended over the surface of water.

Water supply for towns. A plentiful supply of water fitted for drinking, culinary, and detergent purposes, is so essentially an article of every-day use, that in all ages, wherever a quantity of human beings have been congregated together, contrivances have necessarily been resorted to, to procure a supply: in some situations wells are sunk to a considerable depth, from which water is lifted by means of buckets, pumps, or like contrivances; in

others, the rain-water falling on the roofs of houses is caught and husbanded in suitable receptacles, or, —as was much practised in ancient times, where large populations existed,—rivers are diverted for their use from their natural channels, and conducted over valleys and through mountains in artificial courses having a small but continuous decline.

Much has been written and said of the plentiful supply of water brought into ancient Rome and towns in Italy, Spain, and other places, by means of aqueducts; but the streams supplying these aqueducts would yield but little water in the dry summer and autumn weather, as is proved from the number of sources from which water was frequently brought to a town. Ancient Rome, according to some writers, was supplied from no less than twenty aqueducts, all deriving their water from different sources. These aqueducts were built at separate times, and they were doubtless made to supply a pressing want; for although in wet and moderate seasons, probably one-third this number would have yielded a supply adequate to the demand, it is much to be doubted if this was the case in seasons of drought; especially as the ancients made no provisions by means of impounding reservoirs to store a supply from wet to dry seasons.

In ancient times, water was brought to a town from rivers or springs more elevated than the town itself, and was distributed through fountains to the inhabitants, who fetched it in vessels to their houses.

In modern times, excessive floods are frequently stored in large reservoirs, to yield a supply to our towns in seasons of drought; or water from a neighbouring river, or from deep wells sunk in a subterranean reservoir, or water-bearing stratum situated below the level of a town, is frequently lifted by means of pumps, worked by steam or water power, through a line of cast-iron pipes into a reservoir of sufficient altitude to admit of its being conducted from thence through other pipes to the highest house in a town; and it is no uncommon thing at the present time to lift water from 200 to 300 feet in elevation for this purpose.

But the greatest improvement lately made for supplying towns with water consists in the arrangements for conveying it, when raised to a sufficient altitude, in cast iron or lead pipes, into the house of every inhabitant, even to the upper story, so that this necessary article can always be secured by the turning of a cock: it is also distributed in the same manner for watering roads, and for use in case of fire; and it is principally in the excellent system of distribution, which perfection in the art of making the pipes has induced, that renders modern water-works superior to those of ancient times.

It is of the utmost importance to every house to be supplied plentifully with wholesome soft-water, and there are now few places in which this cannot be accomplished at a cheap rate.

The modern cost of supplying water to a large town may now be taken at a low estimate per head of the population supplied, according to the facilities or difficulties that exist for procuring and distributing the supply: as a general rule, river-water, when unpolluted with the drainage of a town, or the rain-water flowing down the sides of steep hills of a retentive character, when properly filtered, is superior in quality, and better adapted for most domestic uses than the brightest spring-water, owing to its freedom from saline matter, which is usually denominated softness.

All rain and surface water should, however, be carefully filtered be

fore it is supplied for domestic uses, not only to free it from earthy mechanical impurities, but to rid it of organic matter, which in summer time and warm weather is always mixed with such water in a greater or less degree, and the presence of which renders it unwholesome for drinking or culinary uses. It is principally owing to its freedom from organic matter that spring-water, though usually hard, is preferred to river-water as a beverage.

Water-ways, in ship-building, the planks of the deck which are close to the timbers

Water-wheel, a wheel turned on its axis by the weight of water falling upon its circumference, and thus adapted as a machine for deriving power wherever a fall of water can be commanded. For this purpose the wheel is erected in a vertical position upon a horizontal shaft or axis, and the periphery of the wheel is so formed that the greatest possible effect shall be received from the weight or gravity of the falling water. To obtain this effect, the rim of the wheel is provided with small troughs or buckets in which the water is received, and its weight made active in carrying down that part of the periphery on which the loaded buckets are situated. As they approach the lowest position, they become emptied, and are thus prepared to be carried upward during the revolution of the wheel, while the descending buckets are successively receiving their supply from the fall of water. Water-wheels are commonly distinguished according to the height of the fall in comparison with the diameter of the wheel, and the position at which the water acts upon the buckets. Thus if the depth of fall equals the diameter of the wheel, (besides allowing a little declivity below the wheel, for the ready escape of the back-water,) so that the water falls on the highest point of its periphery, the wheel is said to be an 'overshot' water-wheel. If the depth of fall is less, so that the water falls upon the wheel, only a little above the level of its centre, the wheel is called a 'breast' wheel. And if the depth of fall is so little that the water acts by impulse only against the lower parts of the wheel, it is called an 'undershot' water-wheel. Water-wheels are now made in the most improved manner of iron, the arms being of wrought iron, the centres of cast iron, and the buckets of plate iron. A water-wheel thus constructed consists of a centre boss, and shaft, arms, buckets, and shrouding, the latter being the term applied to the rims of the wheel, between which the buckets are enclosed. In order to derive the greatest working effect from a given fall of water, the principal object is to shape the buckets so that they shall retain the water during the longest possible period. One great difficulty experienced in seeking this object has been the opposition exerted by the air to the admission of the water into the buckets; and, to counteract this evil, several methods have been devised. The only efficient remedy yet introduced is that invented by Mr. Fairbairn, and which he denominates the 'Ventilating Water-wheel,' the general object of which is to prevent the condensation of the air, and to permit its escape during the filling of the bucket with water, as also its re-admission during the discharge of the water into the lower mill-race. Several wheels erected and fitted upon this principle have proved entirely successful in realizing a maximum useful effect from a given fall of water. All these wheels are formed with wrought-iron arms radiating from cast-iron centres to the periphery, and so disposed that the entire structure is in a state of tension, and the motion of the wheel being communicated from internal

toothed wheels fixed to the shrouding. As applied to common breast-wheels adapted for falls not exceeding 18 or 20 feet, these ventilating buckets effect so great an improvement, that if the wheel is plunged in back-water to a depth of 5 or 6 feet, its uniform speed is not impeded. In these wheels the sole of the buckets is close, and the tail end of them being turned up at a distance of 2 inches from the back of the sole-plate, and running parallel with it, terminate within about 2 inches of the bend of the bucket, immediately above it. The water in entering the bucket drives the air out through the aperture into the space behind, and thence into the bucket above, and so on in succession. The converse occurs when the buckets are emptied, as the air is enabled to enter as fast as the wheel arrives at such a position as to permit the water to escape. (For a more copious description see *Water-wheels with ventilating buckets.*)

There are many cases in which it is of importance to know the proportion of power necessary to give different degrees of velocity to a mill; but as the construction of mills and the purposes they serve are various, it is perhaps impossible to find any law of universal application. Mr. Banks, in his 'Treatise on Mills,' has drawn a conclusion which he appears to consider invariable, namely, that "when a wheel acts by gravity, its velocity will be as the cube root of the quantity of water it receives."

But supposing a wheel to raise water by means of cranks and pumps on Mr. Banks's principle, Buchanan thought it might easily be demonstrated, that by reducing the velocity of the wheel to a certain degree, the wheel would raise more water than would be necessary to move it at that velocity,—a thing evidently impossible.

In this view it would seem tnat there is no actual case in which Mr. Banks's conclusions will hold true. But, however they may apply to other mills, the experiments of Buchanan seem to prove at least that they do not apply to cotton-mills. On the ground of some experiments made at different times, and with all the attention possible, did he presume to call in question an authority for which the highest respect is entertained.

In January, 1796, he measured the quantity of water the Rothesay old cotton-mill required; first, when going at its common velocity, and secondly, when going at half that velocity. The result was, that the last required just half the quantity of water which the first did. It is to be observed, that in these experiments the quantities of water were calculated from the heads of water and apertures of the sluices.

From these experiments he inferred, "that the quantity of water necessary to be employed in giving different degrees of velocity to a cotton-mill must be nearly as that velocity."

He was satisfied with this experiment, and the inference drawn from it, till some gentlemen well acquainted with the theory and practice of mechanics expressed their doubts on the subject. He had then recourse to another experiment, which he considered less liable to error than the former.

The water which drives the old cotton-mill falls a little below it into a perpendicular-sided pond, which serves as a dam for a corn-mill at some distance below it. To ascertain, therefore, the proportional quantities of water used by the old mill, nothing more was necessary than to measure the time the water took to rise to a certain height in that pond; and accordingly, on the 1st of May, 1798, he

made the experiments noted in the following Table:

Number of experiments	1	2	3	4
Revolutions of one of the upright shafts per minute . . .	46	46	24	23
Rise of water in the pond in inches . .	5	5	5	5
Time in minutes and seconds	6·58	6·57	14·45	15·0

The first and second experiments were made with the mill at its common velocity; the third and fourth at nearly half that velocity.

The time which the mill required to use the same quantity of water in these experiments may be taken, in round numbers, as follows: the proper velocity at 7 minutes, and half that velocity at 15 minutes.

The result of these experiments approaches very nearly to that of 1796. The difference may be accounted for by the small degree of leakage which must have taken place at the sluices on the lower end of the pond; and the time being greater in the third and fourth experiments, the leakage would of course be greater.

Smeaton and others have proved in a very satisfactory manner, that "the mechanical power that must of necessity be employed in giving different degrees of velocity to the same body, must be as the square of that velocity." But it appeared to Buchanan, that the result of the above experiments may be easily reconciled to this proposition, by considering what Smeaton says immediately afterwards:—"If the converse of this proposition did not hold true, viz. that if a body in motion, in being stopped, would not produce a mechanical effect equal or proportional to the square of its velocity, or to the mechanical power employed in producing it, the effect would not correspond with its producing cause." It is to be observed, that Smeaton's experiments were made on the *velocity* o bodies, free from *friction* a *causes of resistance;* but there is not only friction, stacles, to be removed: periments made on frict proved that the friction kinds of bodies increases i proportion to their velocit the velocity of a cotton- work may be considered a chanical effect; and, if s correspond with its pr cause.

The preceding experim the Rothesay mill are undo correct and consistent wi principles of motion and and also with the experim Smeaton on mills and mec power.

The mechanical power the quantity of water o wheel, multiplied into its city when the wheel, fal other circumstances rema same; and since the mec effect is measured by the res multiplied into the velocity working point when the fri constant, if the quantity of w diminished by its half, eith the resistance, or half the with which it is overcome, taken away, otherwise the not be an equilibrium betw power and effect. But at t time it is to be observed, increased velocity lessens t tion of the intermediate ma and consequently a greate would be produced by the velocity, as appears to be t by the experiments. Ther however, in the detail of t periments, sufficient data b it becomes easy to arrive useful conclusion.

Roberton, an engineer eminence, made observati these experiments, allegi the conclusions of Banks gi satisfactory evidence that care and judgment are n

making such trials. It appeared to Roberton, that the wrong conclusions which have been drawn by many writers on this subject, have wholly arisen from misapprehending some of Sir Isaac Newton's fundamental principles of mechanics, and from a love of establishing theoretical expressions rather than strict observations of the invariable laws of nature,—expressions such as these, viz. *quantity of motion, instantaneous impulse.*

Taking a constant portion of time (viz. a second) to be the measure of a body, and an instant to be measure of the effect it produces; or by taking time as the measure of the cause, and space as the measure of the effect,—as to an *instantaneous* effect, Roberton argues that it is an absurdity in itself, as well as in mechanics,—we can form no idea of a body put into motion, without the acting power or body act upon the body put into motion for some *time*, and also over some *space;* and to suppose otherwise, leads us entirely out of the sound principles of mechanics.

In mechanics every effect is equal to its producing cause. In the case of a power acting on a body producing motion, and also this body acting against another power which retards its motion, if the causes of action and resistance are each measured by the *time* the motions are produced and retarded, the result will be equal.

If they be measured by the *space* over which they act, the results will be equal; and this is an universal principle, whether applied to accelerating power and motion, as gravity, &c., or to machines which act constantly and uniformly. Yet, in the case of uniform motion, space or time may be used at pleasure; as from the uniformity of space and time they become a common measure.

To illustrate this, suppose the body A acted upon by the power of gravity through the space A B, in a portion of time which we will call one. When it arrives at B, it meets with another medium of resistance, which is ten times greater than the former: the body A will be resisted in proportion to the cause of action and resistance; that is to say, if the *time* of action were one second, the *time* of resistance will be one-tenth of a second, and the distance A B will be to the distance B C as ten to one; so that whether *space* or *time* be taken as the measure of action, the same must be taken for the measure of the effect, to have the results proportionate and equal. But if the cause be measured by *time*, and the effect by *space*, the results will be as the squares of the time, or, which is the same thing, as the squares of the velocity.

Thus, suppose a body in motion, with a velocity of one, has a power to penetrate into a bank of earth 1 foot: if the same body, with a velocity of two, strike the bank, it will penetrate to the depth of 4 feet; for the velocity is double, and the time of action is double, and therefore the results will be compounded of both, that is, as the square of the velocity.

From the above it may be inferred that if equal bodies be acted upon by unequal powers, the time requisite to produce an equal motion will be reciprocally proportionate to the powers; that is to say, if a power of ten act upon a body for one second of time, and the power of one act upon an equal body for ten seconds, they will produce equal velocities. But the spaces through which the bodies are carried are very unequal, being as

ten to one; and if the square roots of the powers producing the effects be taken, that will give the times they take in carrying the body acted upon through equal spaces.

But it is obvious this doctrine has no more to do with the operation of machines than to supply their first starting from rest to the motion necessary for working. When this is acquired, the power applied and the power of resistance balance each other, and whatever be the motion the machine moves at, the same power will carry it on, (if it be upheld,) provided the machine act in such a manner as not to accumulate resistance by the accumulation of motion, which is the case in forcing fluids through pipes, &c. In cases of this kind, the nature of the machine must be particularly kept in view, and no law whatever adopted to explain the resistance the acting body meets with, but what is simply deduced from the very machine which is under consideration; but, in most cases, any machine may be considered as acting purely on a statical principle. The raising of weights, or overcoming friction, Roberton considers purely as acting on that principle; and when the power of action is equal to the resisting power, the machine is indifferent to motion or rest. If the machine be at rest, the power will not move it, being a balance to the resistance. If the machine be set in motion, the power will keep it in the same motion, (provided the power be upheld,) the same as equal weights hung over a pulley, or in the opposite scales of a beam. If they be at rest, they will remain so; and if they be put in motion, they will endeavour to persevere in the same.

The above doctrine of a statical principle is proved in the most satisfactory manner by the experiments made at the old mill of Rothesay, the motion of the water-wheel being exactly proportional to the quantity of water expended, and therefore an exact and equal load upon the wheel; that is to say, the *buckets were equally full* when the mill moved at its *ordinary motion*, or at *half that motion*.

The effect, therefore, of letting more water on a wheel is not to lodge a greater quantity in the buckets, but to supply the same quantity when the wheel is in a greater motion.

Banks, however, made his experiments agree with his theory, yet Roberton took no trouble in inquiring into them, alleging it would be to little purpose to have done so.

"Suffice it to say," he adds, "that the very small quantities of water which Banks made use of, and the slowness of the motion of his wheel in his experiments, give no ground for placing the smallest dependence on them; and when compared with the more judicious and accurate experiments of Smeaton, they dwindle into contempt."

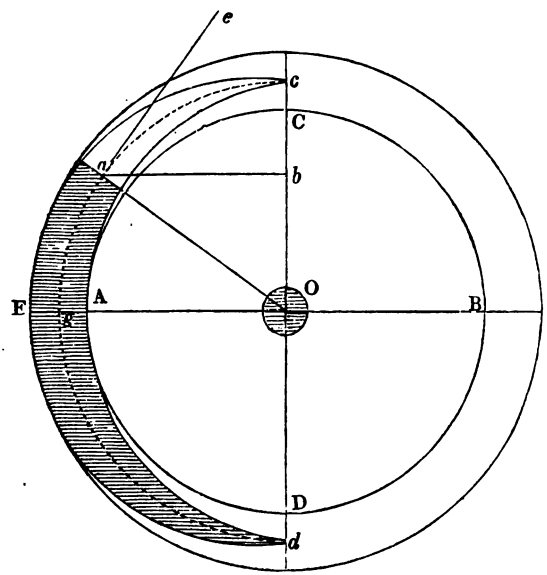
Roberton further says, that "Smeaton, in running his wheel at nearly 3 feet in the second, brought it nearly to a maximum, and lost but about one-fourth or one-fifth of the original effect (alluding to his *overshot* wheels). Banks, at his highest motion, run his wheel about 1 foot in the second, and reducing it to one-half of that motion, the same quantity of water then expended was capable of performing four times the work; and by deduction from thence, it appears plain that his wheel (from his own theory) would perform about twenty times the quantity of work which Smeaton's could perform with the same quantity of water, and about sixteen times more than nature; so that the observation (alluding to the theory of Banks) is very just in saying that, by reducing the mo-

tion of the wheel, it is demonstrable it would raise more water than supply itself."

Water-wheels (*Overshot*). The best water-wheel is that which is calculated to produce the greatest effect when it is supplied by a stream furnishing a given quantity of water with a given fall.

The mechanical effect depends on the proportion of the wheel's diameter to the height of the fall, and on the velocity of the circumference of the wheel. These are the two principal parts to be considered in the theory of wheels, but there are also some other points which ought to be attended to, because the effect is much decreased when they are neglected.

Of the proportion of the radius of the water-wheel to the height of the fall.—Let A B C D be the wheel, and E A the depth of the buckets; then, according to experiments on water-wheels, it appears that the rotatory form of the water in the buckets is nothing at *c* and *d*, and



that it increases nearly, if not accurately, in the direct ratio of the distance from *c* or *d*, and is greatest at A. That is, the force at any point *a* in a direction *e a*, or perpendicularly to the radius, is as *a c*.

A slight consideration of the figure is sufficient to demonstrate that the wheel will not produce the greatest effect when it receives the water at the upper point c, and that there must be considerable advantage in making the wheel of a greater diameter, so that it may receive the water at the same point between A and c, the point which will insure the greatest effect thus calculated.

Let c = that portion of the circumference which is to be loaded with water; and *a* = the arc com-

prehended between the point where the water flows upon the wheel and the horizontal line E A; also make b = the area of the stream supplying the buckets. Then the solid which represents the effective force will be

$$\tfrac{1}{2} b \times \left(\frac{c^2 - 2x^2}{c - x}\right),$$

which is to be the greatest possible; or

$$\frac{c^2 - 2x^2}{c - x}$$

= a maximum. By the principles of maxima and minima this takes place when

$$x = c\,(1 - \sqrt{\tfrac{1}{2}}) \text{ or } x = \cdot 2929\, c.$$

Accordingly the arc $c - x$ must be the quadrant dg or 90°, and the arc $x = 37{\cdot}27°$.

Hence we have this important practical maxim. A water-wheel will produce the greatest effect when the diameter of the wheel is proportioned to the height of the fall, so that the water flows upon the wheel at a point about $52\frac{3}{4}°$ distant from the summit of the wheel.

If r be the radius of the wheel to the extreme part of the bucket, and h the effective height of the fall, then $h = r\,(1 + \sin. 37\frac{1}{4})$, or $h = 1{\cdot}605\,r$; for the sin. $37\frac{1}{4} = {\cdot}605$. Also $\cdot 623\,h = r$. Therefore, when the effective height of the fall is determined, the radius of the wheel is easily calculated. When the effective fall is $\frac{5}{9}$ of the whole fall, if we make h the whole fall, $r = \cdot 554\,h$, or $1{\cdot}108\,h$ = the diameter of the wheel.

The effective height of the fall is less than the true height by as much as is necessary for giving the water the same velocity as the wheel before it flows upon it.

In low falls a wheel would work with advantage in a considerable depth of tail-water, provided the buckets were of a suitable form for moving through the water, and the effective fall made through a very accurate sweep, so that the sweep, and not the form of the bucket, should confine the water upon the wheel.

Of the velocity of the circumference of the wheel to produce a maximum effect.—It is necessary to premise, that the velocity with which the water flows upon the floating boards or buckets is considered to be equal to the velocity of the wheel, and to strike against the floats as nearly as possible in the direction of the motion of the wheel.

Let x be that part of the fall which gives the necessary velocity v to the water, when the effect is a maximum; v will then be the velocity of the circumference of the wheel. Also, make a = that part of the fall which would correspond to the velocity of the circumference of the wheel when the power would be equal to the friction of the loaded machine only; or when the useful effect would be nothing. Now if h be the whole fall, the effective force of the water on the wheel will always be proportional to $h - x$, when the effect is a maximum; and to $h - a$, when the useful effect, or work done, is nothing.

Hence $v\,(\overline{h - x} - \overline{h - a})$ must be a maximum; or $v\,(a - x)$ = a max.; but $v = x^{\frac{1}{2}}$, therefore $x^{\frac{1}{2}}\,(a - x)$ = a max., which, according to the rules of maxima and minima, takes place when $a = 3\,x$.

It is evident that the value of a must entirely depend on the nature of the machine; for if there be many moving parts between the power and the resistance, the friction will be greater, and consequently a will be less. The machine must be very simple indeed, if the friction be less than one-half the moving power, and it will often amount to

two-thirds of it. If we suppose it to be two-thirds, then

$$a = \frac{h}{3},$$

and consequently

$$x = \frac{h}{9},$$

and

$$v = \sqrt{\frac{64\frac{1}{3}h}{9}} = 2{\cdot}67\sqrt{h}.$$

Hence, when the friction amounts to two-thirds of the moving power, the velocity of the circumference of an overshot wheel in feet per second, should be 2·67 times the square root of the whole height of the fall, in feet.

Again, that part of the fall is to be determined, which will give the water the same velocity as the wheel; and since

$$a = \frac{h}{3}, \text{ and } 3x = a,$$

we have

$$x = \frac{h}{9}.$$

Hence, when the friction is two-thirds of the power, that part of the fall which will give the water the proper velocity is one-ninth of the whole height.

These results may, then, be usefully compared with the experiments of Smeaton; at the same time it is obvious that his experiments were not adapted for arriving at general conclusions, because the water was always delivered upon the same wheel: for it is clear, from the preceding investigation, that every particular wheel must have its particular maximum.

In Smeaton's experiments on overshot wheels, the wheel was 2 feet in diameter; therefore the height of the fall should be $2\frac{1}{4}$ feet. Now the square root of $2\frac{1}{4}$ is 1·5; and 1·5 × 2·67 = 4·005, that is, the velocity of the wheel should be 4 feet per second; or it should make 38 turns per minute. Smeaton infers that "the best velocity for practice" will be when a wheel of 2 feet diameter makes 30 revolutions per minute. (Miscellaneous Papers, p. 51.) But his model had much more friction in proportion to the effective force of water on the wheel than two-thirds, here calculated upon. When, however, the calculation is made according to the friction of Smeaton's model,

$$v = 2{\cdot}4\sqrt{h};$$

and the velocity of the model wheel would come out 3·6 feet per second, or 34 turns per minute. This velocity will perhaps apply correctly enough to overshot wheels, where the water flows on at the summit, and to rough-made machinery; but the former calculation is that which appears to be most correct for the improved kind of wheels here pointed out. It is to be understood, that the friction allowed for includes all the kinds of resistance and loss of force which lessen the useful effect, as well as the resistance of the rubbing surfaces, properly called friction. Many persons may think that two-thirds of the effective force is greatly too much to be lost; it will be well if it draw their attention to lessening the stress on every part of the machinery, and to the importance of having few rubbing surfaces, and other causes of resistance.

On computing the power of overshot water-wheels.—In determining the proportion of the radius of the wheel to the height of the fall, an equation is given for the effective force. Resuming that equation, we have

$$\tfrac{1}{2}\,b\left(\frac{c^2 - 2x^2}{c - x}\right)$$

= the effective force of the water, and

$$\tfrac{1}{2} b v \left(\frac{c^2 - 2x^2}{c - x}\right)$$

= its mechanical power. But the quantity of water expended in maintaining this power will be $b v$. Hence, the quantity of water expended is, to its mechanical power, as

$$1 : \tfrac{1}{2}\left(\frac{c^2 - 2x^2}{c - x}\right).$$

When the wheel is supplied at the summit, $x = \frac{1}{2}$ c; and therefore the quantity of water expended is to its mechanical power as 1 : ½ c. Or the power is equal to half the weight of water supplied to the wheel.

The same relation takes place when $x = 0$; that is, when the wheel is supplied at the height of the axis. Hence, when the radius of a breast-wheel is equal to the effective height of the fall, its power will be the same as that of an overshot wheel supplied at the summit.

When the wheel is supplied at the point which produces the greatest effect, $x = \cdot 2929\, c$; and consequently the quantity of water expended is to its mechanical power as 1 : 0·5857 c: this effect is greater than when the wheel is supplied at the summit in the ratio of 1·1714 : 1.

These comparisons will convey some useful information to many readers; and they may sometimes suggest to scientific writers the advantage of studying the actual nature of machines; for relations so extremely obvious and simple could never have been overlooked by any one who might have condescended to examine the subject.

The power of a water-wheel may be considered under two points of view; each of which has its peculiar use. If we wish to compare it with any other first mover, then we shall have to calculate its mechanical power. But when it is desirable to compute the r it will overcome at the point, the effective force s calculated.

When the water flows wheel, either at or above the mechanical power is

$$\tfrac{1}{2} b v \frac{c^2 - 2x^2}{c - x}$$

cubic feet of water, or

$$31{\cdot}25\, b v \frac{c^2 - 2x^2}{c - x}$$

where $b v$ is the quantity expended in a second, in cu c the part of the circumfer tween the lowest point of t and the place where th flows upon it, in feet; an part of the circumference the point which is level axis, and that where th flows upon the wheel, in f

Suppose the mechanic of a horse is estimated at moving with a velocity of per second, then a wat will be equal

$$\frac{31{\cdot}25\, b v (c^2 - 2x^2}{200 \times 3\tfrac{3}{8} (c - x)} \text{ hor}$$

$$= \frac{\cdot 00426\, b v (c^2 - 2x^2}{c - x}$$

When the water flows at the summit or at the lev axis, the mechanical p 31·25 $b v c$ lbs., or it is = $b v c$ horses.

When the water flows o degrees distant from the the mechanical power is $b v c$ lbs., or = ·005 $b v$ Since in this case, c = 127 of the circumference, we h 127¼ × ·0174533 r; and ·554 h; and v = 2·67 substituting these quanti have 122·176 $b h^{\frac{3}{2}}$ lbs. = chanical power; or ·0164 the number of horses, wh the whole height of the fal

and b = the area of the aperture through which the water flows upon the wheel, in feet.

The effective force is 31·25 $b\,c$ lbs. when the water flows on either at the summit or at the level of the axis.

When the water flows on at 52¾ degrees distant from the summit of the wheel, the effective force is 37·192 $b\,c$ lbs. or 45·746 $b\,h$ lbs.

Of the power of breast-wheels.—When the water flows on below the level of the axis of the wheel, it may be termed a breast-wheel.

Let y be the distance below the axis measured on the circumference, then

$$\frac{c^2\,b\,v}{2\,(c+y)}$$

equal the mechanical power in cubic feet of water, or

$$\frac{31{\cdot}25\;c^2\,b\,v}{c+y}\text{ lbs.}$$

When $y = c$, the power will be reduced one-half, and when $y = 2\,c$, it will be reduced two-thirds, and so on.

If we assume that the mechanical power of an undershot wheel is half that of an overshot one "under the same circumstances of quantity and fall;" then it will be an advantage to employ an undershot wheel whenever the fall is less than three-tenths of the radius of the wheel. But since the radius of the wheel may in many cases be diminished, it does not appear to be desirable to employ an undershot wheel in any case, except where the quantity of water is great and the fall inconsiderable.

Water-wheels with ventilated Buckets. Since the time of Smeaton's experiments in 1759, little or no improvement has been made in the principle on which water-wheels have been constructed. The substitution, however, of iron for wood, as a material for their construction, has afforded opportunities for extensive changes in their forms, particularly in the shape and arrangement of the buckets, and has given, altogether, a more permanent and lighter character to the machine than had previously been attained with other materials. A curvilinear form of bucket has been generally adopted, the sheet iron of which it is composed affording facility for being moulded or bent into the required shape.

From a work entitled 'Mécaniques et Inventions approuvées par l'Académie Royale des Sciences,' published at Paris in 1735, it appears, that previous to the commencement of the last century, neither the breast nor the overshot water-wheels were much in use, if at all known; and at what period, and by whom they were introduced, is probably equally uncertain. The overshot wheel was a great improvement, and its introduction was an important step in the perfecting of hydraulic machines; but the breast-wheel, as now generally made, is a still further improvement, and is probably better calculated for effective duty under the circumstances of a variable supply of water, to which almost every description of water-wheel is subjected. Improvements have taken place during the last and the present centuries. The breast-wheel has taken precedence of the overshot wheel, not so much from any advantage gained by an increase of power, on a given fall, as from the increased facilities which a wheel of this description, having a larger diameter than the height of the fall, affords for the reception of the water into the chamber of the bucket, and also for its final exit at the bottom.

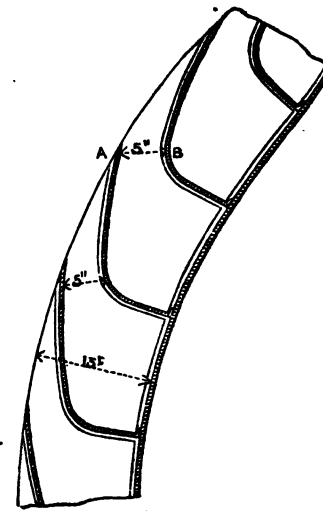
Another advantage of the increased diameter is the comparative ease with which the wheel overcomes the obstruction of backwater. The breast-wheel is not only less injured from the effects

of floods, but the retarding force is overcome with greater ease, and the wheel works for a longer time and to a much greater depth in back-water.

The late Dr. Robison, Professor of Natural Philosophy in the University of Edinburgh, in treating of water-wheels, says, "There frequently occurs a difficulty in the making of bucket-wheels, when the half-taught millwright attempts to retain the water a long time in the buckets. The water gets into them with a difficulty which he cannot account for, and spills all about, even when the buckets are not moving away from the spout. This arises from the air, which must find its way out to admit the water, but is obstructed by the entering water, and occasions a great sputtering at the entry. This may be entirely prevented by making the spout considerably narrower than the wheel: it will leave room at the two ends of the buckets for the escape of the air. This obstruction is vastly greater than one would imagine; for the water drags along with it a great quantity of air, as is evident in the water-blast, as described by many authors."

In the construction of wheels for high falls, the best proportion of the opening of the bucket is found to be nearly as five to twenty-four; that is, the contents of the bucket being 24 cubic feet, the area of the opening, or entrance for the water, would be five square feet. In breast-wheels which receive the water at the height of 10° to 12° above the horizontal centre, the ratio should be nearly as eight to twenty-four, or as one to three. With these proportions, the depth of the shrouding is assumed to be about three times the width of the opening, or three times the distance from the lip to the back of the bucket, as from A to B, fig. 1, the opening being 5 inches, and the depth of the shroud 15 inches.

Fig. 1.



For lower falls, or in those wheels which receive the water below the horizontal centre, a larger opening becomes necessary for the reception of a large body of water, and its final discharge.

In the construction of water-wheels, it is requisite, in order to attain the maximum effect, to have the opening of the bucket sufficiently large to allow an easy entrance and an equally free escape for the water, as its retention in the bucket must evidently be injurious, when carried beyond the vertical centre.

Dr. Robison further observes, "There is another and very serious obstruction to the motion of an overshot or bucketed wheel. When it moves in back-water, it is not only resisted by the water when it moves more slowly than the wheel, which is very frequently the case, but it lifts a great deal in the raising buckets. In some particular states of back-water, the descending bucket fills itself com-

pletely with water, and in other cases it contains a very considerable quantity, and air of common density; while in some rarer cases it contains less water, with air in a condensed state. In the first case, the rising bucket must come up filled with water, which it cannot drop till its mouth gets out of the water. In the second case, part of the water goes out before this; but the air rarefies, and therefore there is still some water dragged or lifted up by the wheel, by suction, as it is usually called. In the last case, there is no such back-load on the rising side of the wheel, but (which is as detrimental to its performance) the descending side is employed in condensing air; and although this air aids the ascent of the rising side, it does not aid it so much as it impedes the descending side, being (by the form of the bucket) nearer to the vertical line drawn through the axis."

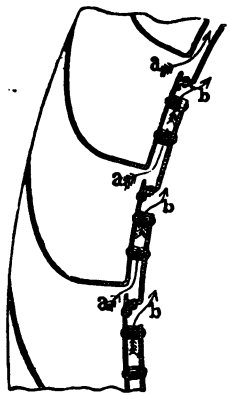
These were the difficulties under which the millwrights of Dr. Robison's time laboured; and the remedy which they applied (and which has since been more or less continued) was to bore holes in what is technically called the 'start' of the bucket. This was the only means adopted for removing the air from the buckets of overshot wheels, in order to facilitate the admission and emission of the water. In lower falls, where wheels with open buckets were used, or straight float-boards radiating from the centre, large openings were made in the sole-planking, exclusive of perforations in each bucket, in order to relieve them from the condensed air. The improved construction of the present time is widely different, the buckets being of such a shape as to admit the water at the same time that the air is making its escape.

During the early part of 1825, and the two succeeding years, two iron water-wheels, each of one hundred and twenty horse-power, were constructed in Manchester for Messrs. James Finlay and Co., of the Catrine Works, under the auspices of the late Mr. Buchanan, and also for the same Company at Deanston, in Perthshire, of which firm Mr. James Smith (Deanston) was then the resident partner. These wheels are still (1850) in operation, and taking them in the aggregate, they may probably be considered as some of the most powerful and the most complete hydraulic machines in the United Kingdom. The construction of these wheels, and others for lower falls, first directed attention to the ingress and egress of the water, and led to the improvements which have since been introduced.

The object of these modifications may be generally stated to have been, for the purpose of preventing the condensation of the air, and for permitting its escape, during the filling of the bucket with water, as also its re-admission during the discharge of the water into the lower mill-race.

Shortly after the construction of the water-wheels for the Catrine and Deanston Works, a breast-wheel was made and erected for Mr. Andrew Brown, of Linwood, near Paisley. In this it was observed, when the wheel was loaded, and in flood-waters, that each of the buckets acted as a water-blast, and forced the water and spray to a height of six or eight feet above the orifice at which it entered. This was complained of as a great defect, and, in order to remedy it, openings were cut in the sole-plates, and small interior buckets were attached to the inner sole, as shown at *b*, *b*, *b*, fig. 2. The air in this case made its escape through the openings *a*, *a*, *a*, into the inner bucket, and passed upwards, as is shown by the arrows, through *b*, *b*, *b*, into the interior of the wheel. By these means it will be observed

Fig. 2.



that the buckets were effectually cleared of air whilst they were filling, and that during the obstructions of back-water, the same facilities were afforded for its re-admission, and the discharge of the water contained in the rising buckets. The effect produced by this alteration could scarcely be credited, as the wheel not only received and parted with the water freely, but an increase of nearly one-fourth of the power was obtained, and the wheel, which still remains as then altered, continues, in all states of the river, to perform its duty satisfactorily.

The amount of power gained, and the beneficial effects produced upon Mr. Brown's wheel, induced a new and still greater improvement in the principle of construction: the first wheel erected on this, which has been called the 'ventilated' principle, was one designed for Mr. Duckworth, at the Handforth Print-Works, in the neighbourhood of Wilmslow, in Cheshire.

Close-bucketed wheels labour under great difficulties when receiving the water through the same orifice at which the air escapes, and in some wheels the forms and construction of the buckets are such as almost entirely to prevent the entrance of the water, and to deprive the wheel of half its power. These defects may be easily accounted for where the water is discharged upon the wheel in a larger section than the opening between the buckets: under such circumstances the air is suddenly condensed, and, re-acting by its elastic force, throws back the water upon the orifice of the cistern, and thus allows the buckets to pass without their being more than half-filled. Several methods have been adopted for relieving them of the air: the most common plan is, by cutting holes in the sole-plates, close to the back of the buckets, or else making the openings between them much wider, in order to admit the water, and at the same time to allow the air to escape. All these remedies have been more or less effective; but they labour under the objections of a great waste of water and much inconvenience, by the water falling from the openings down upon the lower part of the wheel, exclusive of the puffing and blowing when the bucket is filling.

Other remedies have been applied, such as circular tubes and boxes attached to the sole-plates, which, extending upwards, furnish openings into the interior of the wheel for the air to escape; but these, like many other plans, have been, to a certain extent, unsuccessful, owing to the complexity of their structure, and the inadequate manner in which the objects contemplated were attained. In fact, in wheels of this description it has been found more satisfactory to submit to acknowledged defects, than to incur the trouble and inconvenience of partial and imperfect remedies.

In the improvements made by Mr. Fairbairn, these objections are to a great extent removed, and a

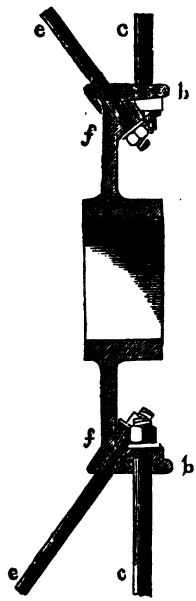
thorough system of ventilation has been effectually introduced. Before entering upon the description of this new principle of ventilation, it is necessary to remark, that in climates like Great Britain and Ireland, where the atmosphere is charged with moisture for six or seven months in the year, it is no uncommon occurrence for the rivers to be considerably swollen, and the mills depending upon water are either impeded or entirely stopped by back-water; while at other times a deficiency of rain reduces the water-power below what is absolutely required to drive the machinery. On occasions of this kind, much loss and inconvenience are sustained, particularly in mills exclusively dependent upon water as a motive power, and where a number of work-people are employed.

On the outskirts of the manufacturing districts, where the mills are more or less dependent upon water, these inconveniences are severely felt; and in some situations these interruptions arise as frequently from an excess of water as from a deficiency in the supply. To remedy these evils, reservoirs have been formed, and wheels have been constructed to work in floods; but although much has been accomplished for diminishing these injurious effects, and giving a more regular supply in dry seasons, yet the system is still imperfect, and much has yet to be done, before water can be considered equal, as a motive power, to the steam engine, which is always available where the necessary fuel is at hand. It is therefore obvious, that any improvement in the construction of water-wheels, whereby their forms and requirements may be better adapted to meet the exigencies of high and low waters, will contribute much to the efficiency and value of mills situated upon rivers subjected to the changes alluded to.

Water-wheels (Ventilated) as adapted to low falls.—The first wheel constructed upon the ventilated principle was erected at Handforth, in Cheshire, in the summer of 1828: it proved highly satisfactory to the proprietors, Messrs. Duckworth and Co., and gave such important results as to induce its repetition, without variation, in cases where the fall did not exceed the semi-diameter of the wheel.

In the earlier construction of iron suspension wheels by the late Mr. J. C. Hewes, the arms and braces were fixed to the centres by screws and nuts upon their ends, as shown in fig. 3. The arms *c*, *c*, passed through the rim *b*, *b*, and

Fig. 3.



the braces *e*, *e*, which traverse the angle of the rim *f*, *f*, are, as nearly as possible, in the position and

form adopted by Mr. Hewes. This arrangement, although convenient for tightening up the arms and braces, was liable to many objections, arising from the nuts becoming loose, and the consequent difficulty of keeping the wheels true to the circle, and the arms and braces in an uniform state of tension: gibs and cotters were therefore substituted for the nuts and screws, and since their introduction into the large wheels of the Catrine Works, Ayrshire, the objections have been removed, and the arms and braces are not only perfectly secured, but the periphery of the wheel is retained in its true and correct form.

Having noticed the obstructions offered to the entrance of the water into buckets of the usual form, and the consequent loss which ensues from its retention upon the wheel, after its powers of gravitation have ceased, it is now necessary to show the means whereby those defects were removed, and also to exhibit the relation existing between the breast and the undershot wheels. These terms have, however, become nearly obsolete, as every description of water-wheel may now be properly called a breast-wheel; and in every fall, however low, it is generally found advantageous for the water to act by gravitation, and not by impulse, as during the early periods of the industrial arts.

Water-wheels (Breast), with close Soles and ventilated Buckets. The preceding statements have been principally confined to the form of bucket, and description of water-wheel, adapted for low falls. It is therefore necessary to describe the best form of breast-wheels for high falls, or those best calculated for attaining a maximum effect on falls varying from one-half to three-fourths of the diameter of the wheel. This is a description of water-wheel in common use, and is generally adopted for falls which do not exceed 18 feet in height, and, in most cases, is preferable to the overshot wheel. It possesses many advantages over the undershot wheel, and its near approximation to the duty, or labouring force, of wheels of the former description, renders it applicable in many situations, especially where the fall does not exceed 18 or 20 feet, and where the wheel is exposed to the obstructions of back-water. In the latter case, wheels of larger diameter are best adapted; and provided sufficient capacity is left in the buckets, such wheels may be forced through the back-water without diminution of speed. Every wheel of this kind should have capacity in the buckets to receive a sufficient quantity of water to force the wheel, at full speed, through a depth of 5 or 8 feet of back-water; and if these provisions are made, a steady uniform speed, under every circumstance of freshes and flood-waters, may be attained.

Irrespective of the advantages of clearing the buckets of air, additional benefit is obtained by the facility with which the water is discharged, and the air again admitted, at the bottom of the fall, during the period of the emptying of the bucket into the tail-race. This is strikingly illustrated where the wheels labour in back-water, as the ventilated buckets rise freely above the surface, and the communication being open from one to the other, the action is rendered perfectly free, at almost any depth to which the wheel may be immersed.

In breast-wheels constructed for falls of 25 feet or upwards, the stone-breast is not required, as the buckets are formed with narrow openings, and the lip being extended nearer to the back of the following bucket, the water is retained much longer upon the wheel. Under these circumstances, a stone-

breast is of little or no value, when attached to a wheel with close buckets, on a high fall.

The construction of the breast-wheels, as above described, is almost exactly similar to that for the lower falls; malleable iron arms and braces being common to both, as also the axle, shroud, and segments. These, when duly proportioned and properly fitted to each other, form one of the strongest, and probably the most permanent structures, that can be attained in works of this description.

Water-wheel (common Breast, not ventilated), as constructed by Messrs. Fairbairn and Lillie, between the years 1825 *and* 1827. These wheels were executed upon the plan of the overshot or breast-wheel, taking the water at an elevation nearly equal to that of its height. Four wheels of this description were constructed for Messrs. James Finlay and Co., for a fall of 32 feet, at Deanston, in Perthshire, and two others, for the same firm, at the Catrine Works, in Ayrshire, on a fall of 48 feet. Taking into consideration the height of the fall, the Catrine water-wheels, both as regards their power and the solidity of their construction, are, even at the present day, probably among the best and most effective structures of their kind in existence. They have now (1850) been at work upwards of twenty years, during which time they have required no repairs, and they remain nearly as perfect as when they were erected.

It was originally intended to have erected four of these wheels at the Catrine Works, but only two have been constructed; preparations were, however, made for receiving two others, in the event of an enlargement of the reservoirs in the hilly districts, and more power being required for the mills. This extension has not yet been wanted, as these two wheels are equal to 240 horse-power, and are sufficiently powerful, except in very dry seasons, to turn the whole of the mills.

These water-wheels are 50 feet in diameter, 10 feet 6 inches wide inside the bucket, and 15 inches deep on the shroud; the internal spur segments are 48 feet 6 inches diameter, 3¼ inches pitch, and 15 inches broad on the cog; the large spur-wheels are 18 feet 2½ inches in diameter, 3¼ inches in the pitch, and 16 inches wide on the cog; and the pinions are the same width and pitch, but are 5 feet 6 inches in diameter; the large bevel-wheels are 7 feet in diameter, 3½ inches in the pitch, and 18 inches broad on the cog, their proportions being calculated to convey the united power of all the four water-wheels, should the original design ever be completed.

The water for the supply of the wheels is conveyed from the river Ayr in a canal and tunnel, and from thence, along the side of a rising bank, to the wheel-house. From this point it is conveyed to the water-wheels by a large sheet-iron trough, supported on iron columns.

When viewed from the entrance, the two wheels already erected have a very imposing effect, each of them being elevated upon stone piers; and as the whole of the cisterns, sluices, winding apparatus, galleries, &c., are considerably elevated, they are conveniently approached in every part. Under the wheels is a capacious tunnel, terminating at a considerable distance down the river.

Water-wheels on a principle introduced by M. Poncelet, have attained some considerable reputation on the Continent; and as Mr. Fairbairn has constructed one of them for Mr. De Bergue, it is necessary to allude briefly to the peculiarities it possesses.

The buckets are of a curvilinear

form, and are quite open at the back, without any sole-plate; so that they are perfectly ventilated. The water impinges upon them at nearly the lowest point of the wheel, the shuttle being arranged to draw upwards; and as the water enters, it follows the inside cavity of the bucket, rises and falls over into the next in succession, and so on. By this system the force of the water is expended on the wheel itself, instead of losing much of its power in rushing along through the wheel-race, as generally occurs in even well-made undershot wheels.

M. Poncelet has treated this subject at much length in his able work on water-wheels; but it may be observed, that a practical improvement might be effected by terminating the lower stone platform of the race somewhat short of the vertical line of the centre of the wheel, as the escape of the water would be facilitated, and the ascending buckets would be more easily relieved of their contents: this is a point of such importance for all wheels, that it must equally apply to this form.

Mr. De Bergue obtained nearly seventy-eight per cent. of power from a breast-wheel, with a good fall, when the periphery was travelling at a velocity of 6 feet per second.

He had erected several of Poncelet's wheels, and thought well of them; indeed, for certain situations it was thought they were preferable to any other form, although M. Poncelet had never yet been able to obtain very superior results from wheels erected under his own superintendence.

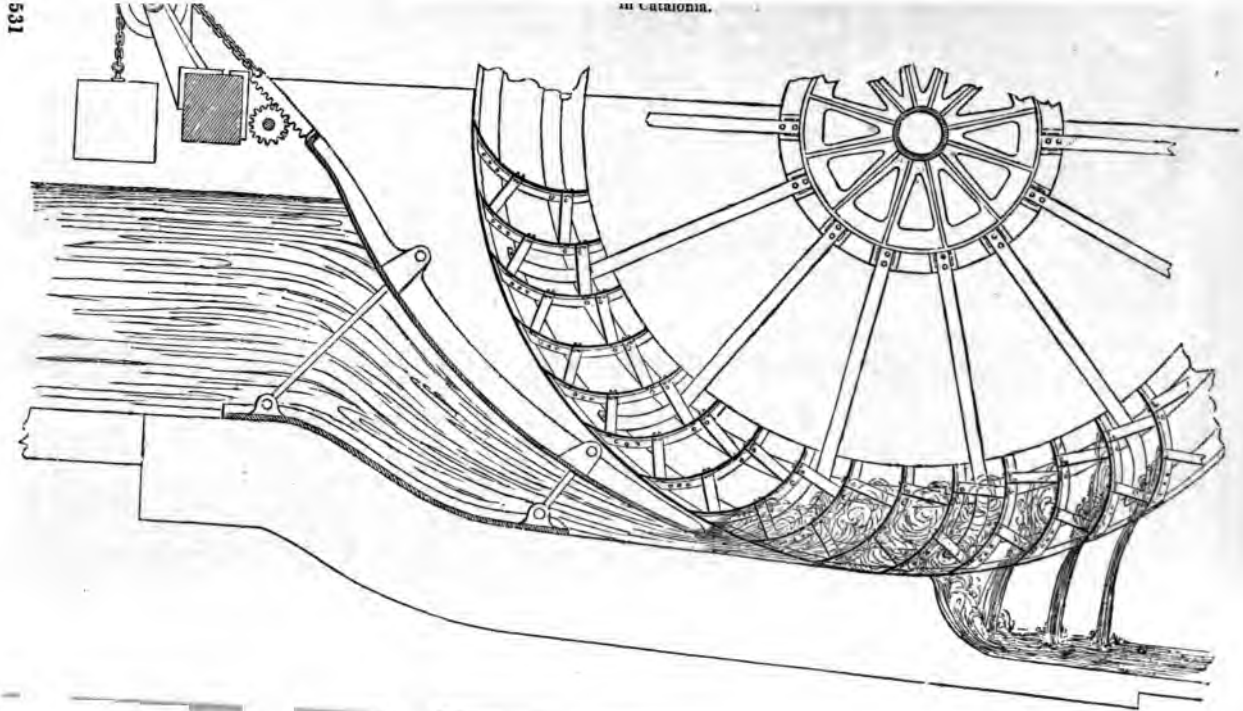
Mr. De Bergue has explained the construction of a wheel, on this principle, erected at the Loubregat, near Montserrat, in Catalonia; one of the same kind having been already erected by him at Gerona, between Barcelona and Belgrade.

The diameter was 16 feet 8 inches, and the width was 30 which, with a fall of 6 fe inches, passed 120,000 cubic of water per minute, wher periphery travelled at a veloc 11 to 12 feet per second. A dinary breast-wheel would re to be 90 feet wide, to use a tageously that quantity of w It was found that the veloc the periphery should be abo per cent. of that of the water ing through the sluice; and these data the power of the would be about 180 horse-po

The buckets were of a c form, and made of wrought ⅛th of an inch thick; and it sl be observed that there was a l number of buckets than usual that the water came upon the a tangent, through an orifi such a form and dimensions allow the buckets to fill easi the rapid speed at which the phery passed before the sl This great primary velocity very important, as it caused a siderable saving in the gearin the mill.

The main shaft was forme a hollow cylinder of cast ir feet 6 inches diameter, in lengths, bolted together; an arms were of wrought iron, very light, and of the same as those of a paddle-wheel steamer, and placed very clos gether. The strain was bro entirely upon the main shaft, the weight of the wheel was reduced to about thirty tons, w was very little for so power machine.

The sluice was formed of iron plates, with planed jo bolted through the flanches form one large shuttle of the tire breadth of the wheel, an motion was regulated by radial rods, between the stone apron the back of the sluice, which c thus be raised with great fac by racks and pinions, and be r



lated by the ordinary governor, the weight of the sluice being in a great degree supported by the water flowing beneath it on to the wheel. It moved very accurately between the side walls of the pen-trough, and cup-leathers at each side prevented any waste of water.

This kind of wheel was less affected by back-water than any other form, and the water acted upon it with its full power of velocity, without any impediment from the air in entering, as there was no sole-plate: the buckets filled and emptied with great facility. It is therefore most satisfactory for all falls under 8 feet in height, though the principle differs essentially from that generally taken as the basis of construction of water-wheels.

Waved, in heraldry, an indented outline, indicating honours originally acquired at sea

Way-shaft, in steam engines, the rocking-shaft for working the slide-valve from the eccentric

Wax, the substance of which the honey-combs of bees are composed, and which is of considerable use in branches of art

Weathercock, a vane made in the shape of a cock

Weather-gage, in navigation. When a ship is to windward of another, she is said to have the *weather-gage* of her.

Weather-glass, an instrument to foreshow the change of weather and the temperature of the air

Weather-moulding, a label, canopy, or drip-stone, over a door or window, intended to keep off water from the parts beneath

Wedge. The wedge is a solid piece of wood or metal, generally made in form of a triangle prism, of which the two ends or bases are equal and similar plane triangles, and the three sides rectangular parallelograms; and it is called rectangular, isosceles, or scalene, according as its equal and similar bases are composed of right angles, isosceles, or scalene triangles. As a mechanical power, the wedge performs its office, sometimes in raising heavy bodies, but more frequently in dividing or cleaving them; hence all those instruments which are used in separating the parts of bodies, such as axes, adzes, knives, swords, coulters, chisels, planes, saws, files, nails, spades, &c., are only different modifications that fall under the general denomination of the wedge.

Weighboard, in mining, clay intersecting a vein

Weight and power, when opposed to one another, signify the body to be moved and the body that moves it. That body which communicates the motion is called the power, and that which receives it the weight.

Weights and Measures. The system of weights and measures used in France at present, in all legal transactions, is called the 'metrical system,' from the fact of its being based upon the unity of length, which is designated 'the mètre.'

Before the great revolution of 1793, the separate provinces of the French kingdom had their different systems of measures; just as in England the different counties had theirs, before the introduction of the imperial measures. There was, consequently, the same confusion attached to the meanings of the different terms employed, which led our own Government to simplify the question. An acre in Normandy did not mean the same as an acre in Picardy; a pound in Paris differed from a pound elsewhere. But here the analogy between the conduct of the two Governments ceases. That of France reformed the whole system of weights and measures, and based the new one upon natural and easily verifiable principles,—whilst our own retained the arbitrary and illogical system of the middle ages,

contenting themselves with merely fixing a sort of uniformity in the definitions of the several terms.

The merit of having originated the metrical system is due to the government of Louis XV., who named a commission to pursue the investigations necessary to decide the principles upon which it was to be carried out. After a very serious consideration of the case, and a numerous series of observations carried on during the reign of Louis XVI., and under the Convention, the Academy of Sciences decided that all the different weights, measures, and coinages should be established according to certain definite relations to the dimensions of the globe itself. These are, to all human perception, invariable. If therefore the standard were lost, it is always possible to refind it, by a repetition of the same sort of observations which gave rise to the fixing it in the first instance. The beat of a pendulum, chosen by our own Astronomical Board, is a very uncertain base for such calculations; for the conditions of the vacuum, the temperature of the atmosphere, the specific gravity of the pendulum, nay, perhaps, even the magnetic currents, may affect the length of the space it goes through, in a manner able to affect calculations which require such mathematical exactitude as those connected with ascertaining the standard of a perfect system of measures.

The length of the earth's meridian was ascertained by Messrs. Delambre and Méchain, in the portion between Dunkerque and Barcelona; and by Messrs. Arago and Biot, in the portion between Barcelona and Formentera. The length of the meridian from the pole to the equator, passing through Paris, was then divided into ten million parts; and one of these parts, called the mètre, became the basis of the new system of weights and measures. Maupertuis had previously, in the year 1736, measured a portion of the arc of a meridian passing through the North Cape, and his observations were combined with those of the second commission. In spite of all this care, however, an error was made in fixing the length of the mètre; for the distance from the equator to the pole is really 10,000,738 mètres, instead of 10,000,000. For any practical purpose, however, this error is inapplicable; but it is very unfortunate.

The length of the mètre once ascertained, the other measures were derived from it. All the multiples and sub-multiples were formed on the decimal system, and respectively designated by Greek and Latin prefixes to the name of the unities. Thus, the multiples of the mètre are the *deca*-mètre, ten mètres; the *hecto*-mètre, a hundred mètres; the *kilo*-mètre, a thousand mètres; the *myria*-mètre, ten thousand mètres. In deference to old customs the term 'league' has been retained, and a legal value of four kilomètres affixed to it.

The sub-multiples of the mètre are: the *deci*-mètre, the tenth part of a mètre; the *centi*-mètre, the hundredth part of a mètre; and the *milli*-mètre, the thousandth part of a mètre.

The same prefixes are, of course, applicable to all the other unities.

The unities of length in use for ascertaining the distances of places, are, as said before, the mètre (the kilomètre and the myriamètre) and the league.

The unity of surface is the 'are,' which is a square of ten mètres on a side, or one hundred superficial mètres. The usual multiples and sub-multiples are, the *hect*-are, a square of one hundred mètres on a side; and the *centi*-are, the mètre superficial. The terms usually employed in the sale of land and in agricultural discussions are, simply, those named above.

The unity of weight is the 'gramme,' which is the equivalent of a cube of distilled water (at a temperature of 4° above the 'ice-melting point' of the centigrade scale), measuring a centimètre every way. The multiples and sub-multiples are, as before: the decagramme, ten grammes; the hectogramme, a hundred grammes; the kilogramme, a thousand grammes; the decigramme, a tenth part of a gramme, &c. A thousand kilogrammes, then, would form a cube equal to one measuring a mètre on every side; and it is made the legal ton for heavy weights.

The unity of capacity is the 'litre,' which is the equivalent of a cube measuring one-tenth part of a mètre, or a decimètre, every way. The multiples and sub-multiples are formed as before. They are, the decalitre, the hectolitre, the kilolitre, the decilitre, and the centilitre, &c. The litre is usually employed in expressing the quantities of liquids; the hectolitre in expressing those of grain.

A thousand litres of water thus are equal to a mètre cube every way, and are one ton in weight. Another advantage in this system is, that the tables of specific g serve at once to ascertai weights of the different subst Thus, inasmuch as the s gravity of cast iron is 720 weight of a mètre cube is a 7202 kilogrammes, or 7 to kilogrammes.

The 'franc,' the unity French coinage, is 5 gram weight of an alloy containin parts of pure silver to one o being thus connected wi whole metrical and decimal s

As investigations connect the supply of water are o importance, it may be adde the quantity reckoned as the such calculations is the mo 20 cubic mètres; being nea equivalent of the old 'pon tanier,' or the quantity usu livered by a hole of one in meter in the 24 hours.

The law promulgating t trical system was dated in t 1795. The forced applicat it in legal transactions did n place till nearly 50 years wards.

A Table is subjoined of t ferent French weights and sures, with the correspondin lish equivalents.

Weights and Measures—French, with their English equivalents.

French.	Weight.	English.
Gramme	a cube of one-hundredth of a mètre on a side	15·438 grains troy
Kilogramme	a thousand grammes, or a cube of water one-tenth of a mètre on a side	2·68026 lbs. troy 2·20549 lbs. avoird
La tonne	1000 kilogrammes, or a cube of water 1 mètre on a side	1·015649 ton

English Troy.	Reciprocally.	French.
Grain	equal to	0·06477 gramme
Pennyweight	,,	1·55456 ,,
Ounce	,,	31·0913 grammes
Pound Troy (Imperial)	,,	0·3730756 kilogram
Avoirdupois.		
Drachm	equal to	1·7712 gramme
Ounce	,,	28·3384 grammes
Pound	,,	0·4534148 kilogra
Hundred-weight	,,	50·7826 kilogramm
Ton	,,	1015·649 ,,

convert pounds avoirdupois into kilogrammes, or English tons into French tons, or vice versâ, multiply or divide as follows:

For pounds by	0·4534148
For tons by	1·015649

FRENCH.	LENGTH.	ENGLISH.
. . . . .	about 40,000,000th part of circumference of the globe, or 10-millionth part of a quarter of do.	3·2808992 feet 1·093633 yard
ètre	one thousand mètres . . .	1093·633 yards
mètre	ten thousand mètres . . .	10936·33 yards
nètre	one-hundredth of a mètre . .	0·393708 inch
ièmètre	one-thousandth of a mètre . .	0·0393708 inch

ENGLISH.	RECIPROCALLY.	FRENCH.
ich	one-twelfth of a foot English .	2·539954 centimètres
oot	. . . . .	3·0479449 decimètres
ard	3 feet	0·91438348 mètre
urlong	320 yards	201·16437 mètres
uile	1760 yards	1609·3149 mètres

reduce English measures into French, multiply by; and to reduce French measures into English, divide by:

s to centimètres . .	2·5400
o mètres	0·3047945 — practically 0·3048
to kilomètres . .	1·6093
quare to mètres square	0·09290
ube to mètres cube .	0·028314 . . . . . { A yard cube equals 0·76458 mètre cube

FRENCH.	SURFACE.	ENGLISH.
re	a mètre superficial	1·196033 yards superficial
. . . . .	a square of 10 mètres every side	0·098845 rood
re	„ 100 „ „	2·471143 acres

	RECIPROCALLY.	
l square	contains	0·83697 mètre square
d, or	perch square	25·291939 mètres square
ood	1210 yards square	10·116775 ares
ere	4840 do. do.	0·404671 hectare

In round numbers, the hectare may be taken as equal to 2½ acres.

FRENCH.	CAPACITY.	ENGLISH.
. . . . .	a cube of one-tenth of a mètre on a side	1·760773 pint 0·2200967 gallon
tre	ten litres	2·2009668 gallons
litre	one hundred litres	22·009668 „

ENGLISH.	RECIPROCALLY.	FRENCH.
. . . . .	equal to	0·567932 litre
. . . . .	„	1·135864 „
Imperial	„	4·54345794 litres
ron	„	13·08516 hectolitres

m pressure calculated in pounds per inch superficial into their equivalents calculated ilogrammes per centimètre superficial, or vice versâ, multiply, or divide, by 0·0702774.

Weight in pounds of one cubic foot of the following substances:

st iron	450·	Water	62·5
rought iron . . .	486·	Air	0·075
el	489·	Steam	0·036
ne wood	29·5		

Weight of a Superficial Foot of Plate or Sheet Iron.

No. of the wire-gauge.	Thickness in inches.	Weight in pounds.	No. of the wire-gauge.	Thickness in inches.	Weight in pounds.
	1	40·	12		4·38
	$\frac{7}{8}$	35·	13		3·75
	$\frac{3}{4}$	30·	14		3·12
	$\frac{11}{16}$	27·5	15		2·82
	$\frac{5}{8}$	25·	16	$\frac{1}{16}$	2·50
	$\frac{9}{16}$	22·5	17		2·18
	$\frac{1}{2}$	20·	18		1·86
	$\frac{7}{16}$	17·5	19		1·70
	$\frac{3}{8}$	15·	20		1·54
1	$\frac{5}{16}$	12·5	21		1·40
2		12·	22	$\frac{1}{32}$	1·25
3		11·	23		1·12
4	$\frac{1}{4}$	10·	24		1·
5		8·74	25		0·9
6		8·12	26		0·8
7	$\frac{3}{16}$	7·5	27		0·72
8		6·86	28	$\frac{1}{64}$	0·64
9		6·24	29		0·56
10		5·62	30		0·50
11	$\frac{1}{8}$	5·			

Weight of Rod Iron 1 *foot in length, of the following Dimensions.*

SQUARE IRON.		ROUND IRON.		FLAT IRON.	
Inch.	Pounds.	Inch.	Pounds.	Inch.	Pounds.
$\frac{1}{4}$	0·2	$\frac{1}{4}$	0·14	$\frac{1}{4} \times 1$	0·8
$\frac{3}{8}$	0·5	$\frac{3}{8}$	0·4	$\frac{3}{8}$ 1	1·3
$\frac{1}{2}$	0·8	$\frac{1}{2}$	0·7	$\frac{1}{2}$ 1	1·7
$\frac{5}{8}$	1·3	$\frac{5}{8}$	1·	$\frac{5}{8}$ 1	2·1
$\frac{3}{4}$	1·9	$\frac{3}{4}$	1·5	$\frac{3}{4}$ 1	2·5
$\frac{7}{8}$	2·6	$\frac{7}{8}$	2·	$\frac{1}{4}$ 2	1·7
1	3·4	1	2·7	$\frac{3}{8}$ 2	2·5
$1\frac{1}{8}$	4·3	$1\frac{1}{8}$	3·4	$\frac{1}{2}$ 2	3·4
$1\frac{1}{4}$	5·3	$1\frac{1}{4}$	4·2	$\frac{5}{8}$ 2	4·2
$1\frac{3}{8}$	6·4	$1\frac{3}{8}$	5·	$\frac{3}{4}$ 2	5·1
$1\frac{1}{2}$	7·6	$1\frac{1}{2}$	6·	$\frac{1}{4}$ 3	2·5
$1\frac{5}{8}$	8·9	$1\frac{5}{8}$	7·	$\frac{3}{8}$ 3	3·8
$1\frac{3}{4}$	10·4	$1\frac{3}{4}$	8·1	$\frac{1}{2}$ 3	5·1
$1\frac{7}{8}$	11·9	$1\frac{7}{8}$	9·3	$\frac{5}{8}$ 3	6·3
2	13·5	2	10·6	$\frac{3}{4}$ 3	7·6
$2\frac{1}{4}$	17·1	$2\frac{1}{4}$	13·5	$\frac{1}{4}$ 4	3·4
$2\frac{1}{2}$	21·1	$2\frac{1}{2}$	16·7	$\frac{3}{8}$ 4	5·1
$2\frac{3}{4}$	25·6	$2\frac{3}{4}$	20·1	$\frac{1}{2}$ 4	6·8
3	30·4	3	23·9	$\frac{5}{8}$ 4	8·4
$3\frac{1}{2}$	41·4	$3\frac{1}{2}$	32·5	$\frac{3}{4}$ 4	10·1
4	54·1	4	42·5	$\frac{1}{4}$ 5	4·2
5	84·5	5	66·8	$\frac{3}{8}$ 5	6·3
6	121·7	6	95·6	$\frac{1}{2}$ 5	8·4
7	165·6	7	130·	$\frac{5}{8}$ 5	10·6
8	216·3	8	169·9	$\frac{3}{4}$ 5	12·7

Welding, the operation of combining or joining two pieces of iron or steel, by bringing the surface to be joined to a heat nearly equal to that of fusion

Well, in ship-building, a partition to enclose the pumps, from the bottom to the lower decks, to render them accessible, and prevent their taking damage

Wells. The practice of boring for water, adopted in the province of Artoise, in France, has given the denomination to those wells which are termed *Artesian.* Wells on this principle are very applicable in low level districts covered with alluvial deposit or clay; in such situations springs are seldom found, and water cannot be obtained by sinking an ordinary well, unless at a disproportionate cost. The eastern part of Lincolnshire, which lies between the chalk range called the Wolds, and the sea, is a case in point. It was discovered, perhaps accidentally, in sinking through the clay to the subjacent chalk, that water rose to the surface in a perpetual fountain, and an ample supply was obtained over the whole of that district by the simple operation of boring.

A number of wells of this description have also been executed in the neighbourhood of London by perforating the London clay into the porous bed of the plastic clay formation, and into the chalk.

The principle of operation is simply this. The hole is bored through impervious strata that do not contain water, into lower strata that are fully charged with it, and the water rises by hydrostatic pressure. The height to which it will rise obviously depends upon the inclination of the strata, and other causes which affect the relative levels of the hole that is made, and the subterraneous body of water that has been tapped.

Under most circumstances it is necessary to protect the perforation that is made by sinking iron pipes. The boring is thus secured against the accident of the sides falling in, and another advantage, which is of some importance, is obtained: it may chance that the object is to obtain a supply of soft water which has been ascertained to exist at a certain level, and that the strata which have to be pierced to get to it contain hard or impure water; in such a case the boring would be continued down to the proper depth, and the pipes being plunged into the soft water, it would rise through them, and any water or impurity which might be found in the strata through which they passed would be effectually excluded. If it so happened that at a certain depth below the soft water a mineral water could be obtained, instead of going to the expense of a fresh bore from the surface, it would only be necessary (supposing that both would flow to the same level) to bore through the pipes already fixed, to the mineral water, and insert smaller pipes within the larger ones, for bringing it up to the surface.

The history of the great Artesian well which was completed at Grenelle is one of the most remarkable instances of confidence in the principle, and of perseverance in execution, that is on record. The facts are believed to be substantially as follows:—A person suggested to the authorities that an Artesian well would supply water in a situation where it was greatly required; and after some discussion it ended in his undertaking the work on the stipulation, "No water, no pay." He bored down far beyond the point at which he expected to have terminated his labours; but no signs of water appeared: he persevered, however, till he found that the expenses had ruined him. Under these circumstances, he consulted the celebrated Arago.

who encouraged him to proceed. Again he went to work, and after unparalleled difficulties, at the expiration of six years, and at the depth of 1800 feet, the superincumbent mass was bored through, and the water came boiling up in such quantities, and with such force, as to flood the whole district.

The water, when first obtained, was extremely foul: the partial introduction of an Indian-rubber hose is said to have remedied this, and the water thus procured from the main spring was quite pure, and at a very high temperature.

Well-sinking. The process of boring may be thus briefly described:

The auger, the chisel, or any of the great variety of implements which are required to meet different circumstances and overcome the numerous difficulties which are experienced, are screwed to iron rods, which are usually from 2 to 2½ inches square.

The first rod which is attached to the tool is generally about 6 feet long, and the others are of the uniform length of 20 feet. Each rod has a screw at one end, and a tapped socket to receive a screw at the other, and they fit universally; there is also a 'middle knob' in the centre of each rod, which is used for suspending the rods already fixed, whilst others are being added or detached, as the implement is lowered into the bore, or drawn out of it.

In commencing operations, a stage about 8 or 10 feet square, and 20 feet high, is erected, when the boring takes place from the surface. The men who work the tool stand upon this stage, and a windlass or crab is fixed, chiefly for hoisting and lowering the rods, but mechanical power is also required for assisting in the working when the depth is very great.

A boring handle is attached to the rod, which is used for turning the tool round in boring with an auger, or in 'jumping,' as i quired when cutting through or indurated clay with the c When the boring has proc till it is found difficult to tur rods, or at such times as pra experience dictates, it is nec to draw out the implements a bring up the loose material may be at the bottom of the

Under ordinary circumstan common windlass, or a small gives sufficient power to hoist, and lower the rods; when the bore is of great dep the instruments of unusual si increase of mechanical power cessary. This may be conveni obtained by placing a second on another stage; or, in extra nary cases, horses may be ap on the surface.

An economical mode of b has been adopted with succes some parts of the Continen using a heavy cast-iron bar, 2 or more, armed with a chis the lower end, and surrounde a cylinder or hollow chan which receives through valves brings up the detritus of the forated stratum. This imple is suspended over a wheel or p fixed above the spot in which hole is made, and is raised up let fall by manual labour.

As the rope is raised up down, its tortion gives the c a circular motion, which varie place of cutting at each des When the chamber is full, whole apparatus is raised qu to the surface, and the mat it contains discharged.

In cutting through a hard tum, or under circumstances w iron pipes could be dispensed this plan of boring a hole w doubtless answer; but it is ceived that the bore could sca be made sufficiently straight to mit of pipes being inserted. however, a much less costly thod of executing the work w

it can be made to apply, and is well worth attention.

Well-staircase, a winding staircase of ascent, or descent, to different parts of a building, so called from the walls enclosing it resembling a well, called frequently a geometrical staircase

Weold, or *Weald* (Saxon), a forest

Wharf, a levelled surface, terrace, or embankment, formed on a river or canal bank, or sea-coast, to facilitate the landing and embarkation of persons and goods, and protected by an artificial frontage or structure of masonry or other materials. The natural form of banks and coasts, unless defined by masses of rock, is usually shelving or inclined, so that the depth of water is gradually reduced, and thus prevents the close approach of floating vessels. By the construction of wharf-walls, which are either extended into the deep water, or the foundations of which are sunk so as to permit the subsequent removal of the bank, and thus bring deep water into contact with them, vessels are enabled to come close alongside, and thus discharge or receive their cargoes directly from the wharf. Wharf-walls are constructed of various materials, but are always formed with a slope or batter outwards towards the base, in order to give greater stability to them, and to resist the action of the tide and the waves. Much theory has been expended in attempts to determine the precise forms which should be given to these structures, and, accordingly, some engineers approve of plane-faced walls, while others prefer curved faces; and another theory has been started to explain that a perfectly vertical face is the best of all adapted to resist the influence of waves. Whether this position be theoretically correct or not, however, the value of an extended base, in giving stability, is too well known to need demonstration, and derives support from that intuitive kind of feeling which proceeds directly from the evidence of our senses. Adopting the inclined plane face as a good practical one for wharf-walls, the rate of inclination or batter may be determined from 1 in 8 to 1 in 12, that is, with a total divergence from the perpendicular of $\frac{1}{8}$ or $\frac{1}{12}$ of the total height, being from 1 to $1\frac{1}{2}$ inch in a foot. The front of the wall, if of masonry, may be protected by a row of sheet piling, either of timber or iron. In the former case, the piles are driven close together, and bound along the top with a horizontal tie or waling firmly bolted to the piles. If iron piling is used, the piles are driven at intervals of from three to five feet, and cast-iron plates fitted in between them, being secured within grooves formed in the sides of the piles. The Brunswick Wharf, at Blackwall, affords a good example of this description of piling. The masonry of the wall is founded upon the piling, the length and closeness of the piles being determined with reference to the nature of the subsoil, and the whole of them, are driven to a firm bottom and levelled on the heads, being strongly secured in their position by means of longitudinal and transverse ties or beams, on which the first course of footings was built. The durability of these walls is known to depend greatly upon the kind of mortar or cement used in connecting the masonry or brickwork. Cements known as water-cements, formed with lime which has the property of hardening under water, should be preferred to all others. The thickness of the wall must depend upon its height and the nature of the materials behind it. If these are likely to press severely against the wall, such as clays liable to hold great quantities of water, &c., the thickness of the wall will be required to be greater than if gravel, or other non-retentive material, forms the backing.

Strong ties of iron should in all cases be secured to the front of the wall, passing through it, and being secured by plates and keys in the front, and extending backward to a considerable distance, and secured to a row of piling driven into the solid ground. These land-ties will also considerably assist the wall in resisting the forward pressure of the soil behind it. Immediately at the back of the wall a firm body of concrete, or, at least, well-puddled clay, should be introduced. Whichever of these is used as a backing, it should be consolidated as much as possible, and it will thus resist the admission of moisture behind the wall, which is indispensable to secure its permanent durability. The concrete should be cast in from a height above its intended position, and allowed to set before it is filled in; and if clay be substituted, it should be thoroughly well rammed in, and made as solid as possible.

Wheal. The ancient Cornish called a mine *huel*, which has been corrupted into *wheal*.

Wheel and Axle. This machine is so named by reason of its consisting of a wheel and cylinders, having a common axis with pivots fixed in its extremities, on which the whole may revolve. This very simple and useful contrivance, although usually designated a second mechanical power, requires the consideration of no other principles than those adduced for the lever; it is nothing but a lever, having the radius of the wheel for one arm, and that of the cylinder or axle for the other, the fulcrum being the common centre of both. This machine is also termed the 'Perpetual Lever;' for since the power and the resistance operate respectively at the circumference of a circle revolving about an axis, it is obvious that the rotation must maintain the continuity.

Wheels, in locomotive engines: the well-known inventi taining a rolling prc tion. They receive sponding to the part or tender they suppor trailing, &c. Drivin in size from 4 feet 6 10 feet diameter. trailing wheels vary up to 4 feet 6 inches Tender wheels are u the same size as the trailing wheels of the are attached to.

Wheel-cutting machine, cutting out the teet The most perfect r shaping the teeth o those invented by M Manchester, which ar cutting the teeth of and worm wheels, of or wood. The princ parts of these machi mode of action is as f

Two side frames l ridges from end to e corresponding groove tom of a travelling frame can be adjuste moved by a hand-whe of the machine: at th machine is a strong s vertically, to carry the is fixed on the top of lower part is a large moved by a screw, connected a train of t the sizes of the firs wheels must be such revolution of a handle into a notch after eac lution, shall turn the any point in the pit will move through a di to the pitch. To th frame a slide is attac and joints, in such ma may be fastened to a or at an angle in t either of the length o the machine. The cu wheels for diminish and pulley for com

re carried by the slide.
is a circular piece of
d like a saw, and shaped
aces between the teeth
l, and is raised or low-
ıck at the back of the
d by a pinion and han-
ıvelling frame and slide
ted to the work, and
: wheels arranged for
the given distance, the
set in motion and the
ıtter pressed down upon
he wheel by the handle
ll the space has been
tter is then raised, and
alf a revolution to the
:hed to the worm-wheel
he spindle and work are
ıat the latter is in pro-
ı for the cutter to act
a spur-wheel the slide
lly, for a bevel-wheel it
requisite angle in the
f the length, and for a
l at an angle in the
f the breadth of the

chine used for raising
ɔrked by horses, steam,

in mining, the shaft by
tuff is drawn out of the
: horse or steam whim
illery, a curvilinear cor-
cony within the cupola
l's cathedral, London,
er ecclesiastical build-

is a well-known native
of lime, used by the
as a crayon, or for
designs; for which pur-
.wed into lengths suited
crayon. White crayons
chalks, to be good, must
ut free from grit. From
ıl both whiting and lime
d, and are the bases of
non pigments and co-
in distempering, paper-
:.
at an early date, was
employed for the roof-
ing, if not for the entire construction, of churches

Wicket, a small gate or door within, or a part of a massive or large door or gate for the passage of pedestrians

Willow wood is of many varieties: it is perhaps the softest and lightest of English woods; it is planed into chips, and used for many simple purposes

Wimple, a plaited linen cloth which nuns wear about their necks; also a flag or streamer

Winch or *Wince*, in mining, the wheel and axle frequently used to draw water, &c. in a kibble by a rope

Winch and Axle, a machine constituting a small windlass, and consisting of a cylinder of wood which is capable of turning on its axis between two upright posts of the same material, or between the ends of a cast-iron frame: a lever at one or at each extremity of the cylinder is attached to an iron axle passing through the latter at right angles to its direction, and is furnished with a handle, which is parallel to that axle. The name winch is given to a lever or handle of this kind, and the word is supposed to be derived from the verb *guincher*, signifying, in old French, to turn, or bend in a curvilinear manner. The machine is used to raise a weight vertically, or to draw an object towards it; for which purposes the object is connected with it by a rope or chain which continually passes over the curved surface of the cylinder as the latter is made to turn on its axis by a man acting at the handle. Since the cylinder revolves once while the handle, or the extremity of the lever to which it is attached, is made to describe the circumference of a circle, it is evident that the mechanical power of the machine is precisely that of the wheel and axle. When of a simple form, it is employed to raise water from a well, and earth or some other

material from the shaft of a small mine; and one of a complex nature is used, by means of a crane, to raise casks or heavy packages from the ground to the upper part of a building.

When great weights are to be raised, the machine is usually fixed in a frame of cast iron, which is rectangular on the plan, but its extremities or faces have the form of a triangle, or of the letter A. The axle of the cylinder is supported on a horizontal bar at the middle of each end of the frame, and to the cylinder is attached a toothed wheel which turns with it on the common axis: above this wheel, and parallel to the cylinder, is an iron axle which carries a pinion with teeth working in those of the wheel, and causing the latter to revolve, the pinion itself being turned by means of the lever and handle at one or at each extremity of the frame. A machine of this kind is called a *crab;* and when a weight is to be drawn horizontally or raised above the cylinder, the machine must of course be bolted to the floor or firmly fixed in the ground, in order to prevent it from being moved from its place. In such machines there is generally, at one extremity of the cylinder, a wheel having on its circumference teeth like those of a saw; and a *click* or catch, which turns freely on a pin, is attached by that pin to the side of the frame in such a manner that it may fall between the teeth. By this contrivance, if the handle should break, or the moving power be taken off while the weight is suspended in the air, the latter is prevented from descending.

Machines of this kind are occasionally constructed, which have the power of holding the weight in any part of its ascent or descent without a ratchet-wheel and catch. The only disadvantage attending the machine, when compared with an ordinary winch or capstan, is, that it requires a much greater quantity of rope to raise or move the object through any given distance. It was first proposed in Europe by Mr. George Eckhardt, but machines of a like kind have, it is said, long been in use in the East.

The winch is employed in the common jack, which is used to lift great weights, or to move them through small distances. The handle turns a pinion with teeth, which act on others at the circumference of a small wheel; and on the axle of this is a pinion with teeth, which work in those of a rack-rod. The axles of the wheel and pinions being let into the sides of a case of wood or iron, the revolution of the wheel produces a rectilinear motion of the rack; and one end of the case being fixed to the ground, or against an immoveable object, the extremity of the rack at the opposite end forces forward the body which is to be displaced. Sometimes, instead of a rack, the machine is furnished with a wheel whose axle is hollow, and cut in the form of a concave screw: within this screw is one of the convex kind, which by the revolution of the wheel and its axle is made to move in the direction of the latter, and thus to press before it the object which is to be removed. This machine has, however, considerable friction.

The force exerted by a man in turning a winch vertically, varies according to the position of the lever with respect to the horizon. When the lever, or that part which is perpendicular to the axle, is perpendicular to the ground, and the handle is at the highest or lowest part of the circle described by the end of the lever, the man either pushes the handle directly from him or pulls it directly towards him; and in each case he exerts a power which is estimated at 27 o 30 pounds; but when the lever i

in a horizontal position, the man either throws a great portion of his weight on the handle to press it down, or he exerts his muscular force in a direct manner to pull it upwards; and the force exerted in these positions is estimated at 140 or 160 pounds. The force exerted must very evidently have different values between these quantities in other positions of the winch; and the practice is to cause two men to work at the same time to turn the machine, one being at each extremity of the axle of the cylinder. The levers of the two winches are placed at right angles to one another; consequently, when one man is pushing or pulling horizontally, the other is pressing or pulling vertically, and thus the operation of turning goes on with nearly uniform intensity; the first man working in the least favourable position when the other is working in that which is most so.

Wind (*instrument for measuring the force and velocity of*): a fly (resembling that of a revolving ventilator, or the sails of a wind-mill) is fixed to the small end of the vane of a weather-cock, so as to be turned with its circular disc to the wind; and it consequently revolves by the action of the wind with a rapidity increasing as the force of the wind increases. The revolutions of the axis of this fly are converted by a train of toothed wheels and screws into a vertical motion, by which a pencil is carried downwards, touching the surface of a vertical cylinder, the cylinder having the axis of the weathercock for its axis. As the vertical rod on which the pencil slides is attached to the vane of the weathercock, the point of the compass from which the wind blows is recorded on the side of the cylinder on which the mark is made; while the *quantity* of the wind is represented by the extent of the *descent* of the pencil.

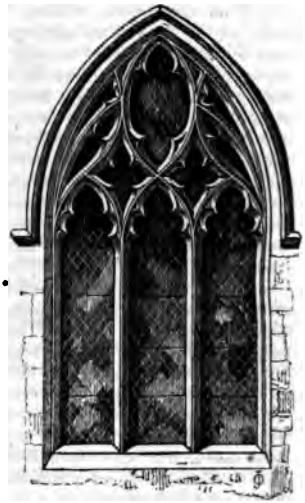
Wind-beam, in ancient carpentry, a cross-beam used in the principals of many ancient roofs, occupying the situation of the collar in modern king-post roofs

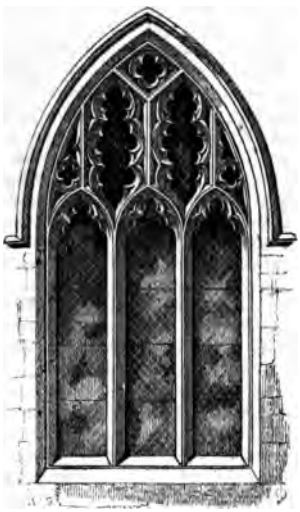
Winding, in ships, twisting on an uneven surface

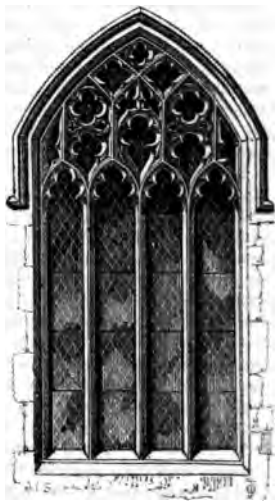
Winding engines. In winding engines for drawing coals from a pit, where a given number of strokes are required in drawing a corf, the diameter of the roll at the first lift must be ascertained. In this case the engine is supposed to have flat ropes, such as are generally used, and which lie upon each other. To find the diameter of a rope-roll at the first lift, it is necessary to know the depth of the pit, the thickness of the rope, and the number of strokes which the engine is intended to make in drawing up a corf or curves; then, the thickness of the rope being known and the number of strokes, the thickness of the ropes upon the roll can be determined, let the diameter of the roll be what it may. Suppose the thickness of the rope to be 1 inch, and the number of strokes 10; then the radius of the roll is increased 10 inches, or the diameter is increased 20 inches, whatever that diameter may be.

Windlass, in mechanics, a machine by which a rope or lace is wrapped round a cylinder: in navigation, a horizontal machine of strong timber, used in merchant ships for heaving up the anchor, instead of a capstan

Wind-mill, a mill which derives its motive power from the impulse of the wind. The building containing the mill-work is usually lofty, and placed on elevated ground. The machinery consists of a shaft, upon one extremity of which arms radiate at right angles, similarly to the spokes of a wheel: upon these, vanes or sails are set at a small angle, (about 22°.) By this means the wind, blowing directly upon the area occupied by the vanes, acts obliquely upon the whole of







causing them all to move in ction transversely to that of ind. Suitable means are led for bringing the sails into tion to confront the current wind. The motion of the s transferred by gearing to machinery required to be , which is most commonly for grinding corn. Wind- were formerly extensively yed, in Holland, to give mo- o pumps for the drainage of The power of the wind is tain and variable in its inten- nd its application as a prime for mechanical purposes is quently limited.

s were almost unknown in ligious and other monumental ures of the Egyptians, Greeks, Romans, but they constitute ssential and distinguishing e of the Gothic, to which they stand in the same rela- as Orders do to the temple ecture of antiquity.

ndows admit of very rich and l decoration, and those in es church, Suffolk, (repre- l on the opposite page,) are iful examples. The varied rance of fancy displayed in the y may possibly be accounted supposing each to have been ift of some pious individual, while he perpetuated his mu- nce, marked also his taste and uity.

e practice of window tracery where had its origin in win- *rouping*, placing two or three t windows beside each other, one or more foil or rosette ows above and between their , in order to fill out the d cell of the vaulting, which necessarily gave the whole an arched outline; and this indicated by a general drip- d or label. It then became able to lighten the irregular *d masses of stone left* between *rforations, and this* was done by piercing these masses, or span- drils, and reducing the solid frame of each foil or rosette to an equal thickness all round, as if several such frames or rings were packed into one great arched opening, which henceforth was regarded as *one* window instead of several. (For further illustration, see art. *Tracery*.)

Wind-sail, in navigation, a sort of ventilator, consisting of a wide tube of canvas shaped like a fun- nel, to convey a stream of fresh air downwards to the hold and lower deck of a ship

Wing transom, in ships, the upper- most transom of the stern-frame

Winze, in mining, a sinking in a lode communicating with one level, for proving the lode or ventilating the drivings

Wipers, the cogs of a horizontal wheel

Wood, in its raw state, contains a large amount of water. This water contains more or less soluble mine- rals, and is called *sap*. By drying wood, a great part, but not all, of this water is evaporated. If wood is dried in a closed vessel, and then exposed to the atmosphere, it quickly absorbs moisture; but the moisture thus absorbed is much less than the wood originally con- tained.

The amount of water varies in different kinds of wood, and also varies according to the season. Wood cut in the month of April contains from 10 to 20 per cent. more water than that cut in the month of January.

The following Table shows the percentage of water in different kinds of wood dried as far as possible in the air:

Beech	18·6
Poplar	26·0
Sugar and common Maple	27·0
Ash	28·0
Birch	30·0
Oak, red	34·7
Oak, white	35·5

Pine, white	37·0
Chestnut	38·2
Pine, red	39·0
Pine, white	45·5
Linden	47·1
Poplar, Italian	48·2
Poplar, black	51·8

Wood cut during the months of December and January is not only more solid, but it will dry faster than at any other period of the year, because the sap by that time has incorporated a great part of its soluble matter with the woody fibre; what remains is merely water. When the sap, during the months of February, March, and April, rises, it partly dissolves the woody fibre; and the drying of the wood is not only retarded, but the wood is weakened, in consequence of the solid matter thus held in solution.

The difference in chemical composition of the woody fibre, in most kinds of wood, is but slight, as the following analytical Table shows:

	Carbon.	Hydrogen.	Oxygen.
Sugar Maple	52·65	5·25	42·10
Oak . . .	49·43	6·07	44·50
Poplar, black	49·70	6·31	43·99
Pine . . .	50·11	6·31	43·58

Wood is generally bought by admeasurement, and its specific gravity is directly in proportion to its amount of carbon, hydrogen, and oxygen. The following Table shows the specific gravity of wood. Water = 1000:

	Green.	Air-dried.
Oak, white . .	1·0754	0·7075
Oak, red . .	1·0494	0·6777
Poplar . . .	0·9859	0·4873
Beech . . .	0·9822	0·5907
Sugar Maple .	0·9036	0·6440
Birch . . .	0·9012	0·6274
Pine, red . .	0·9121	0·5502
Pine, white .	0·8699	0·4716
Ebony . . .	"	1·2260
Guaiac (lignum vitæ) . . .	"	1·3420

Woolf's engine, a steam engine so called from its inventor's name, with two combined cylinders of different diameter, the eduction passage of the smaller cylinder communicating with the steam passages of the other; high-pressure steam being used in the small cylinder, and made to act expansively in the large one, the steam being afterwards condensed in the usual manner. By this arrangement steam is economized, and a considerable saving of fuel is effected.

Work, in mining, ores before they are cleaned and dressed

Working-big, in mining, signifies sufficiently large for a man to work in

Working drawings consist of plans, elevations, sections, and details in full, of the whole, and of all the parts of an edifice, to as large a scale as may be found convenient; generally made in outline, excepting the sectional parts, which are mostly shadowed, in order to make them more obvious to the workman, for whose use these drawings are made

Worm-wheel, a wheel having teeth formed to fit into the spiral spaces of a screw, so that the wheel may be turned by the screw

Wreath, in heraldry, that which is between the mantle and the crest, called also a torce; also a boar's tail, so termed among hunters

Wrought iron. The chemical difference between cast iron and wrought iron consists principally in the degree in which foreign matter is present in each; which is in larger amount in the former than in the latter. This rule is applicable only to a given cast iron, and to the wrought or bar iron which is made from it. There are many cases in which wrought iron contains a larger amount of impurities than cast iron, and still continues malleable; while cast iron of the same composition may be very hard and brittle. Berzelius detected 18

per cent. of silex in a certain kind of bar iron, which was still malleable and useful. One-tenth of that amount of silex will make cast iron brittle. The foreign matters generally combined with pig iron are, carbon, silicon, silex, sulphur, phosphorus, arsenic, zinc, manganese, titanium, chrome, aluminium, magnesium, and calcium. Each of these tends to make iron brittle; therefore, in converting cast into wrought iron, it is necessary, as far as possible, to remove them.

The main difference between pig and wrought iron consists in their mechanical structure, or aggregate form. Pig iron is a homogeneous mixture of impurities and metal. Wrought or bar iron is a mixture of iron more or less pure with a mass of homogeneous impurities, or cinder, the latter filling the crevices between the crystals of the iron. Iron being fusible in proportion to the carbon it contains, if pig metal is melted, and the cinder surrounding it exposed to the atmosphere, the carbon will be volatilized in the form of carbonic acid, and iron of greater or less purity will remain. To keep this iron liquid, a higher temperature is required: unless the temperature is raised, it will crystallize. In this state of metamorphosis its infusibility will increase, and after the expulsion of the carbon, it will contract into a solid mass in opposition to the highest possible heat. By stirring and mixing the pasty iron, small crystals are formed; at first, on account of the partial fusing of the iron, in small particles; but, as the fusibility diminishes, these particles unite by the force of cohesion; and the bodies thus formed may, by exposure to a higher heat, be welded together. The mixing of cinder and iron will prevent the latter from forming large crystals: this result, of course, will be more easily prevented by diligent than by tardy manipulation. Where the pig iron is of such a nature as to keep liquid while the work goes on slowly, still better results will be obtained. This process is analogous to that of salt boiling, in which, by stirring the brine, the formation of large crystals is prevented. If the crystals of iron thus formed cohere, they produce, under the influence of motion, a porous, spongy mass, whose crevices are, if not filled, at least coated, with cinder. If these masses, which are the loups or balls at the puddling furnaces, are shingled or squeezed, the crystals of iron will not unite, but form coated cells with a film of cinder, of greater or less thickness, according to the fusibility of the cinder. Iron in a connected form, and cinder in separate cells, are thus blended in one homogeneous mass. The more this iron is stretched, the more it forms fibres. Fibrous bar iron resembles hickory wood, in being a combination of fibres and spaces. In bar iron, these spaces are filled with cinder. When other circumstances are equal, the strength of the iron will be proportional to the fineness of the fibres. That portion of the iron which is not melted, which crystallizes too fast, or whose premature crystallization cannot be prevented, is in the condition of cast metal, and cannot be converted into fibrous wrought iron. In the puddling furnace it is necessary to prevent crystallization by manual labour.

If the characteristic between wrought and pig iron consists only in a well-regulated mechanical mixture of cinder and iron, fibrous iron should be producible from any cast iron, whether purified or not: this is actually the case. Very fibrous bar iron, which is strong and malleable, is made from very inferior cast metal, from which no impurity has been removed. At Hyanges, in France, very inferior metal is converted by a cheap and skilful pud-

dling process, into a very fibrous bar iron, of great strength and ductility. But this iron is puddled and re-heated at the lowest possible heat; it is then rolled, and is ready for the market. For hoops, rails, and nails, it is a very useful article, but is of no use to the blacksmith. Heated to any temperature above that of the puddling and re-heating furnaces, it returns to its primitive state, in which condition it becomes worse than the cast iron from which it was originally made. None but a very skilful blacksmith can weld it; for, when slightly re-heated, it falls to coarse sandy pieces, or melts like pig iron. That which thus loses its fibrous texture in heating, the smith calls 'burnt iron.'

The philosophy of the improvement of metal consists in the circumstance that a part of its impurities which are originally in chemical combination, are converted into mechanical admixtures. Iron containing a small amount of carbon, silicon, or phosphorus, is always more hard and strong than pure iron. Pure iron is quite soft. Impure iron has the property of crystallizing, on being suddenly cooled: the size of these crystals is proportional to the amount of carbon in chemical combination with the iron, in proportion to other matter. Between the crystals minute spaces are left, which serve for the absorption of oxygen. By this means, silicon and calcium may be oxidized, but not carbon, phosphorus, and sulphur. The metal improves in quality in proportion as oxygen finds access to its impurities.

The absolute cohesion or strength of wrought iron is not dependent upon the degree of purity of the metal, but upon a given mixture of cinder and iron. Pure iron, which is always soft, may be required for various purposes, as in the manufacture of cast steel; but, in most cases, an impure but fibrous iron is preferable. In making wrought iron, the main difficulty consists, not in producing fibres in the first stages of the operation,—for this may be accomplished by almost every experienced manufacturer,—but in retaining these fibres through every subsequent stage of the operation.

Wrought iron of good quality is silvery white and fibrous; carbon imparts to it a bluish, and often a gray colour; sulphur, a dark, dead colour, without a tinge of blue; silicon, phosphorus, and carbon, a bright colour, which is the more beautiful the more the first two elements preponderate. The lustre of iron does not depend principally upon its colour; for pure iron, although silvery white, reflects but little light. A small quantity of carbon in chemical combination, phosphorus, or silicon, increases its brilliancy. Its lustre is diminished by silex, carbon in mechanical admixture, cinder, lime, sulphur, or magnesia. Good iron should appear fresh, somewhat reflex in its fibres, and silky. A dead colour indicates a weak iron, even though it is perfectly white. Dark but very lustrous iron is always superior to that which has a bright colour and feeble lustre. Coarse fibres indicate a strong, but, if the iron is dark, an inferior article. Where the iron is of a white, bright colour, they indicate an article of superior quality for sheet iron and boiler-plate, though too soft for railroad iron. For the latter purpose, a coarse, fibrous, slightly bluish iron is required. Iron of short fibre is too pure; it is generally hot-short, and, when cold, not strong. This kind of iron is apt to result from the application of an excess of lime: its weakness is the result of the absence of all impurities. The best qualities of bar iron always contain a small amount of impurity. Steel ceases to be hard

and strong, when deprived of the small amount of silicon it contains, or if the silicon is oxidized by repeated heating. This is the case with bar iron. If deprived of all foreign admixtures, it ceases to be a strong, tenacious, and beautiful iron, but becomes a pale, soft metal, of feeble strength and lustre. Good bar or wrought iron is always fibrous: it loses its fibres neither by heat nor by cold. Time may change its aggregate form; but its fibrous quality should always be considered the guarantee of its strength. Iron of good quality will bear cold hammering to any extent. A bar an inch square, which cannot be hammered down to a quarter of an inch, on a cold anvil, without showing any traces of splitting, is an inferior iron.

XEB

Xebec, in navigation, a small three-masted vessel, without a bowsprit, principally used in the Mediterranean

Xenodochium, a room in a monastery for the reception and entertainment of strangers, pilgrims, and the relief of paupers

XP. I., the initials of the Greek

XYS

names of Christ; a monogram, represented in paintings and mosaics by the Greek Christians

Xylography, the art of engraving on wood

Xystos, in ancient architecture, a large portico in the gymnasium, for the accommodation of the wrestlers; a sheltered walk

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YAC

Yacht, in navigation, a small ship for carrying passengers

Yard, a court enclosed by walls and other buildings; also a measure of 3 feet: a yard or yerd was anciently a spar or rafter in a timber roof.

Yardland, a certain quantity of land, called, in Saxon, gyrdlander; in Latin, virgata terræ: in some places it is 20 acres of land, in others 24 or 30

Yellow is the first of the primary or simple colours, nearest in relation to and partaking most of the nature of the neutral white; it is accordingly a most advancing colour, of great power in reflecting light. Compounded with the primary red, it constitutes the secondary orange and its relatives, scarlet, &c., and other warm colours.

Yellow Lake. There are several pigments of this denomination, varying in colour and appearance, ac-

YEL

cording to the colouring substances used and modes of preparation. They are usually in the form of drops, and their colours are, in general, bright yellow, very transparent, and not liable to change in an impure atmosphere,—qualities which would render them very valuable pigments, were they not soon discoloured and even destroyed by the opposite influence of oxygen and light, both in water and oil, in which latter vehicle, like other lakes in general, they are bad dryers, and do not stand the action of white lead or other metallic colours. If used, therefore, it should be as simple as possible.

Yellow Ochre, called also *Mineral Yellow*, is a native pigment, found in most countries, and abundantly in our own. It varies considerably in constitution and colour, in which latter particular it is found from a

bright but not very vivid yellow to a brown yellow, called spruce ochre, and is always of a warm cast. Its natural variety is much increased by artificial dressing and compounding.

Yellow Orpiment, or *Yellow Arsenic*, is a sulphurate oxide of arsenic, of a beautiful, bright, and pure yellow colour, not extremely durable in water, and less so in oil. In tint with white lead, it is soon destroyed. It is not subject to discoloration in impure air.

Yew. The yew-tree is common in Spain, Italy, and England, and is indigenous to Nottinghamshire. The tree is not large, and the wood is of a pale yellowish-red colour, handsomely striped, and often dotted like amboyna. It has been long famed for the construction of bows, and is still so employed. The English species is a hard, tough, and durable wood, and lives to a great age. It is also used for the making of chairs, the handles of articles of furniture, &c.

ZEB

Zebra wood is the produce of the Brazils and Rio Janeiro; it is sent in logs and planks as large as 24 inches. The colour is orange brown and dark brown variously mixed. Its beautiful appearance fits it for cabinet-work and turnery.

Zero, the commencement of a scale marked 0, or nothing. It usually denotes the point from which the scale of a thermometer is graduated.

Zeta, presumed to be a room over the porch of a Christian church

Zigzag, a moulding by lines arranged in the manner of the heraldic chevron. Zigzag is found frequently used in Norman and Anglo-Norman architecture. Very many beautiful specimens of this ornament exist in doors and windows of the Anglo-Norman Gothic in England. (See *Doors*, and the *Frontispiece* for an early specimen.)

Zinc. This metal exists in abundance, and is employed for many purposes. It is commonly combined with sulphur in zinc blende, and with carbonic acid in the mineral calamine, which is the most valuable of all its ores. Zinc may be obtained pure by re-distilling in a porcelain retort, which is sold in commerce. It is obtained from the ores as follows: they are first washed and mixed with powdered coke or charcoal, are distilled from

ZIN

an earthen close vessel, with an iron tube passing through its bottom, the upper end of which is open, and the lower end entering a vessel of water. At a bright red heat zinc volatilizes, and is condensed in the water, gases passing off along with it. It is a bluish-white metal, which slowly tarnishes in the air. It is brittle at ordinary temperatures, but at about 300° it is malleable, and may be rolled or hammered into sheets, and retains its ductility when cold. At 400° it may be reduced to powder: it melts at 773°.

Zinc white is an oxide of zinc which has been more celebrated as a pigment than used, being perfectly durable in water and oil, but wanting the body and brightness of fine white leads in oil; while, in water, constant or barytic white and pearl white are superior to it in colour, and equal in durability. Nevertheless, zinc white is valuable as far as its powers extend in painting, on account of its durability both in oil and water, and its innocence with regard to health; and, when duly and skilfully prepared, the colour and body of this pigment are sufficient to qualify it for a general use upon the palette, although the pure white of lead must merit a preference in oil.

Zocle, a name given to a low, plain, square member or plinth supporting a column

Zoophorus, in architecture, a part between the architraves and cornice, so called on account of the ornaments carved on it, among which are the figures of animals

Zyghyr, or *Sigger*, in mining. When a slow stream of water issues through a cranny, it is said to sigger, or zyghyr.

ADDENDA.

ANGLE-STAFFS or *Staff-heads*, vertical heads, generally of wood, fixed to exterior angles of a building, flush with the surface of the plaster, on both sides, for the purpose of fortifying them against accident. They serve also for floating the plaster. Their section is about three-fourths of a circle, with a projecting part from the other quarters, by which they are fastened to the wood-bricks, plugging or bond timber.

Angular modillions, those which are placed at the return of a cornice in the diagonal vertical plane, passing through the angle or mitre of the cornice

Electric Telegraph. The employment of electricity in the transmission of intelligence originated at an early period of the history of electrical science. Plans to this effect had been brought before the public; but all wanted a simplicity of principle and of construction. In 1837, Messrs. Cooke and Wheatstone obtained their first patent for an electric telegraph, applicable to general purposes. This patent has been subsequently followed at short intervals by others, in which the invention has been gradually brought to its present form; the principles originally employed have been progressively rendered more varied and general in their application, and the apparatus more simple in its details. By these improvements the number of wires necessary for the conveyance of intelligence has been reduced, and the construction has been rendered cheaper and more perfect.

The electric telegraph involves in its construction two essential principles. First, that a magnetized needle, which is free to rotate about its centre, being brought near to a wire, through which an electric current is passing, has a tendency to place itself at right angles to that wire; the direction of its motion following a certain invariable law. This fact was the discovery of Prof. Œrsted, of Copenhagen, in 1819. Secondly, that a piece of soft iron, not being permanently magnetic, is rendered temporarily so, during the transmission of an electric current along a wire coiled spirally around it.

The figures to which reference is here made, in the brief description of the apparatus, are, 1. A view of the interior of the single-needle instrument, showing the position of the coil and of the battery connections. 2. A vertical section of the same, through the coil and handle. 3. The handle or key, in the position for giving a signal, part being removed, to render the battery connections more distinct. 4. Plan of the same. The double-needle instrument differs from the single-needle only in the duplication of all the parts.

The coil A, figs. 1 and 2, consists of a light hollow frame of brass or wood, around which are wound, in two portions, about 200 yards of fine copper wire, covered with silk or cotton. This length of wire renders the indications of the needle distinct and prompt, even with a low-battery power, or when forming part of a very extended circuit. The resistance which would be offered by the fine wire of the coil

Fig. 1.

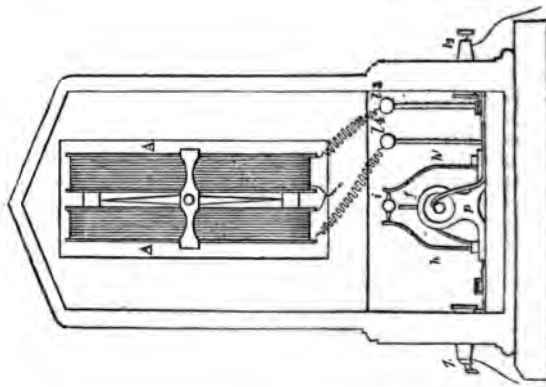


Fig. 2.

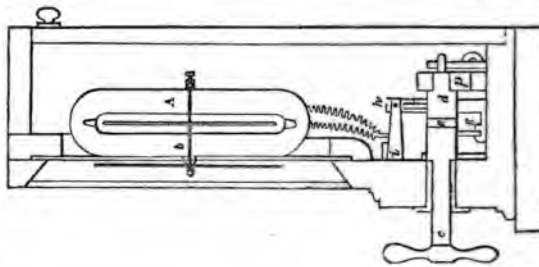


Fig. 3.

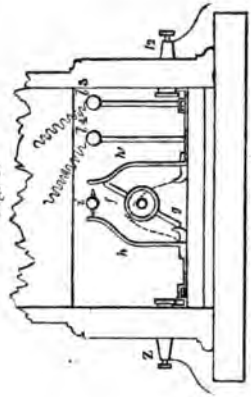
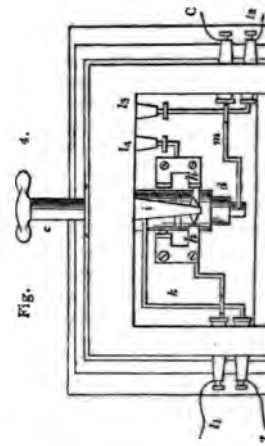
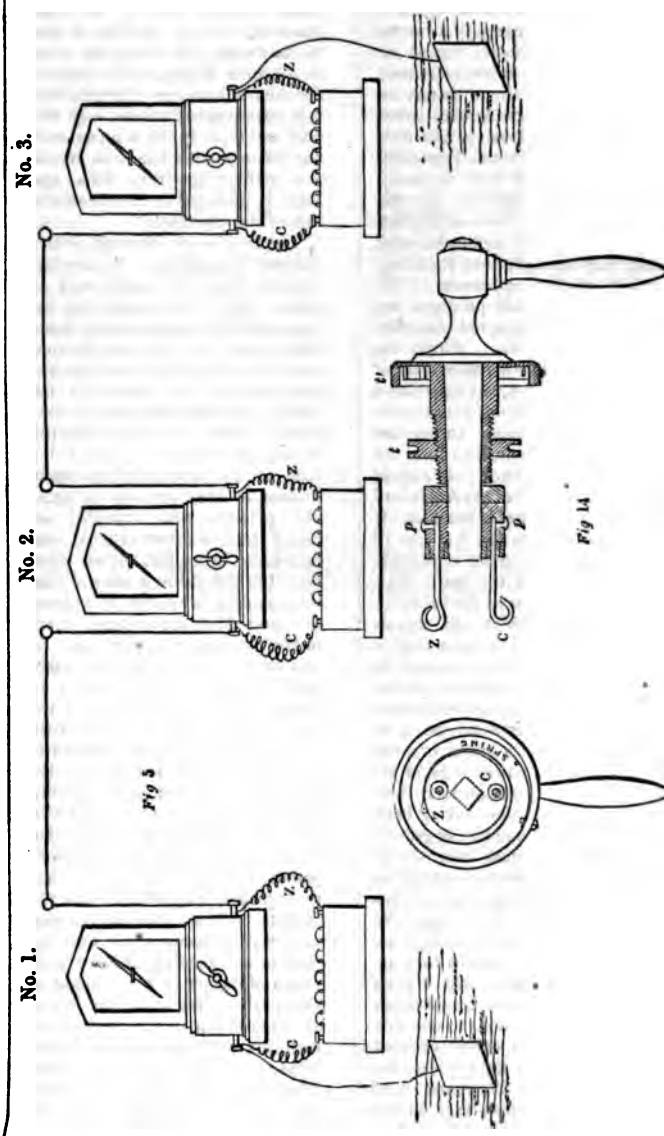


Fig. 4.



(its diameter being about $\frac{1}{150}$th of an inch) to the passage of a current of electricity, derived from an ordinary battery of a few cells only, is overcome by using a battery arrangement of considerable intensity, but which develops the electrical fluid only in small quantity. Or, speaking rather more correctly, we should say, that the electromotive resistance, both of the battery and also of the ordinary circuit, being very considerable, the introduction of the resistance of the coil into the latter produces but little influence upon the transmission of the current. Within the brass frame, and therefore interior to the coils of wire, is suspended a magnetic needle, upon a horizontal axis *b*, which passes across the middle of the frame, and turns on fine pivots at the back and front of the coil. In front of the frame and of the dial of the instrument is fixed on the same axis *b*, a second needle having its poles oppositely placed to those of the first. This outer needle serves as the indicator or pointer, by which the signals are made, and at the same time is acted upon by the coil, though in a less degree than the inner needle. The combination of the two needles being thus rendered astatic, it is necessary to give a slight preponderance to their lower ends, in order that they may recover their vertical position, after having been deflected; and the action of gravity has been found more effectual, in bringing the needle to rest without oscillations, than either springs applied at the sides, or the directive influence of permanent magnets. With the coil and needles thus arranged, it is evident that signals may be given by the combination of successive deflections to one side or the other; the extent of such deflections being limited to any degree that may be found convenient, either by pins fixed on the dial of the instrument, or by stops placed at the sides of the brass frame of the coil. In fact, all that is necessary for rendering these movements of the needle available for the transmission of intelligence, is a contrivance for reversing with ease and rapidity the connection of the battery with the ends of the two conducting wires. This expedient is provided by the handle or key of the instrument.

The conductor through which the electrical current is to circulate must be absolutely complete in all parts. It is not necessary that the material of the circuit be the same throughout, but only that its conductibility be maintained from the one pole of the battery to the other; the slightest want of continuity of the conducting matter, at any part of the circuit, being fatal to the passage of the fluid. So long as the wires for telegraphic purposes were extended between the two points of communication, by being laid within tubes buried in the earth, a second wire was requisite to enable the current to return from the distant station to the point whence it set out. It was well known that the earth itself afforded such a means of return; but the insulation of the wires in the tubes from the earth, could not be rendered sufficiently perfect, to make the use of the earth, as a portion of the circuit, either prudent or desirable. When, however, the wires were suspended in the air, according to Mr. Cooke's patent of 1842, the earth was advantageously employed as half the circuit. All that was found necessary, was to connect the extreme ends of the conducting wire with plates of copper or other metal of two or three feet of surface, buried at some depth in the ground; or with any system of gas or water-pipes, which might afford a continuous metallic path for the fluid to the earth. In either case, the depth of the connection beneath


No. 1.
No. 2.
No. 3.
Fig 5
Fig 14
SPRING
Z
C

the surface must be sufficient to insure certain contact with moist earth or with water, provided that this latter be not confined within any cistern or reservoir. When all these precautions have been taken, the passage of electricity is readily effected, the earth appearing to offer little or no resistance to its progress. According to the law established by Ohm, the resistance of any conductor varies directly as its length, and inversely as its sectional area. The earth may evidently be regarded as a conductor, of which the diameter is infinite, compared with its length, and we might therefore be led to expect the result mentioned above.

To return, however, to the description of the apparatus, the key or handle by means of which the connection of the battery is effected and varied, consists of a cylinder, in which is a middle zone, *e*, of hard wood or ivory, while the ends are of metal. One of these ends, *c*, extending through the case in front, forms the actual handle; while the other, *d*, is turned down to a shoulder and forms a pivot, which rests in a brass collar, *p*. The end *d* carries a steel pin, *f*, projecting upward, and *c*, a similar pin *g*, directed downward. The battery being connected with the terminals z and c, and thence by the brass strips *k* and *m*, of which the extremities rest as springs on the metallic ends of the cylinder, may in fact be considered as having its poles at the two pins, *f* and *g*, which are fixed in those ends. Two springs, *h* and *h'*, are fixed by broad feet to the base of the instrument, and rest by their upper extremities on two studs or points projecting from a brass rod, *i*, screwed into the case in front. These springs form the circuit between the terminal *l* 1, with which one end of the conducting wire is connected, and *l* 4. Between this latter terminal and the external connection, *l* 2, the coil itself, and the brass strip extending from *l* 3 to *l* 2, are interposed. When a signal is being sent through the instrument (supposed to hold the place of No. 2 in fig. 5), the current from No. 1 being considered to enter from the long wire on the line, by the terminal *l* 2, passes along the brass strip to the terminal *l* 3, thence through the coil to *l* 4; then to the spring *h*, across the pin *i*, down the spring *h'*, and to the terminal *l* 1 in connection with the wire leaving the station. Were the instrument in question situated as No. 1 or No. 3, it will be seen that one of the terminals, *l* 1 or *l* 2, according to its position, would be joined to the wire coming from the earth-plate.

When a signal is to be given by the instrument, the handle being turned, as in figs. 3 and 4, one battery-pin, *f*, is brought in contact with the spring *h'*, which is bent back and released from its contact with *i*, while the other battery-pin *g*, is pressed against the foot of the other spring *h*, which at this part is turned up to act as a stop. The current being then supposed to start from the pole *f*, proceeds down the spring *h'*, to the coil and terminal *l* 2, as before; thence along the line through the other instruments, and into the earth at the further extremity of the line. Re-ascending from the earth by the wire connected with the terminal *l* 1, it gains the foot of the spring *h*, with which the second battery pole *g*, is in contact. It will be seen that the direction of the current is different, according as the key is turned to the right or left. The position of the battery wires is such, that the needle shall be deflected in parallelism to the handle. A comparison of fig. 5, in which three instruments are shown in series, with the figures 1, 2, 3, and 4, will render

Fig. 6.

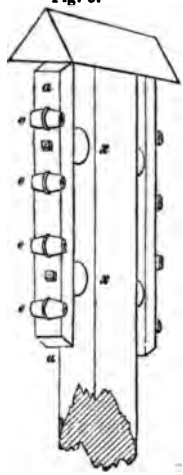


Fig. 7.

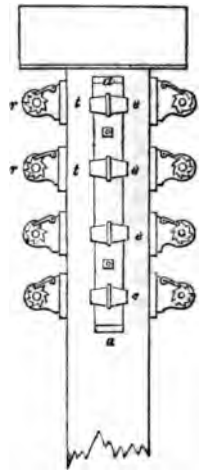


Fig. 8.

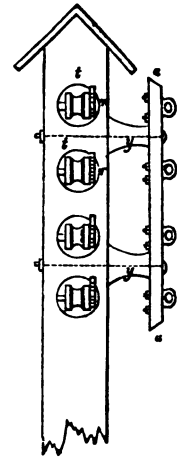
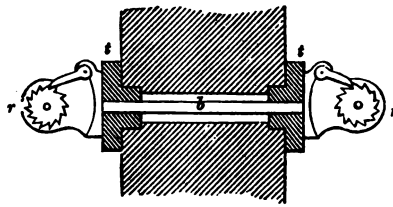


Fig 9.



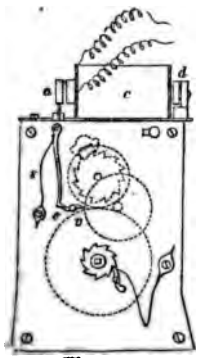


Fig. 11.

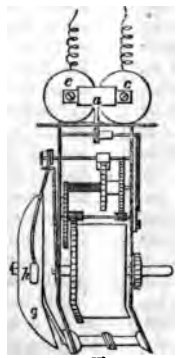


Fig. 12.

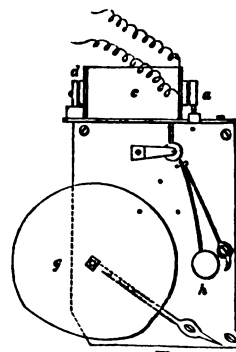


Fig. 13.

the method of connection, both of the two terminal and of the intermediate instruments, sufficiently obvious. The wires on entering a station are designated as 'up' or 'down' wires, according to the portion of the line from which they come. Care must be, of course, taken that all the instruments in one series are similarly joined to the up and down wires, so that the course of the current may be alike in all. At the extreme 'up station' the earth connection becomes the 'up wire,' and at the opposite terminus it takes the place of the 'down wire.'

The electric fluid is represented as starting from one pole of the battery only, and, after traversing the circuit, returning to the other pole. It is, however, more consonant with the theories deduced from the observation of electrical phenomena, to suppose that force is developed equally at both poles of the battery.

The second principle is that of the temporary magnetization of soft iron by the electric current, applied for the purpose of sounding an alarum at a distant station, in order to summon the attendant to his instrument. The same principle has been employed from an early period of the invention, both by Mr. Cooke and by Prof. Wheatstone, to transmit visible signals by causing the rotation of a disc, bearing letters or figures, or of a hand or index pointing to characters on a fixed dial; but in England the needle telegraph has been universally adopted, in preference to any other form. Many improvements have, however, been effected within the last few years by Prof. Wheatstone in the construction of the mechanical telegraph, as it has been named in contradistinction to the needle instrument. The same gentleman has also succeeded in substituting for the voltaic battery in the working of this telegraph, the magneto-electric machine, in which the current is derived by induction from a permanent magnet. The improvement which was effected by this adoption of a source of power, alike energetic and unalterable, will be immediately perceived. Telegraphs on this plan of construction have been erected in Prussia and France, and, were it not for some very marked advantages connected with the use of the needle signals, they could hardly fail to become general.

The ringing of the alarum was originally effected by the direct action of the voltaic magnet upon the hammer of the bell; but this method has been long superseded. The apparatus generally in use for this purpose is shown in a front and back view in figs. 11 and 13, and in a side view at figure 12. An electro-magnet is formed by coiling fine insulated copper wire around two cylinders of very soft pure iron. These coils, *c c*, are then connected by two of their ends, in such a manner that the direction in which the wire is wound about the iron cores may be alike in both. The iron cylinders are joined together at one end by a cross-piece *d*, likewise of soft iron, so that the whole then forms a horse-shoe magnet, having however its two sides parallel. In front of the free ends or poles of this magnet, which is fixed on the top of the plates of the alarum, an armature *a*, of soft iron, is placed at such a distance that it may be strongly attracted by the electro-magnet when the circuit is completed through its coils. The armature moves on an arbor, upon which a detent or catch *e*, is fastened, and so arranged that it is disengaged from a small fly *v*, whenever the attraction takes place. This disengagement allows a train of clock-work, impelled by a spring or weight, to run down, and by the action of a scape-wheel and pal-

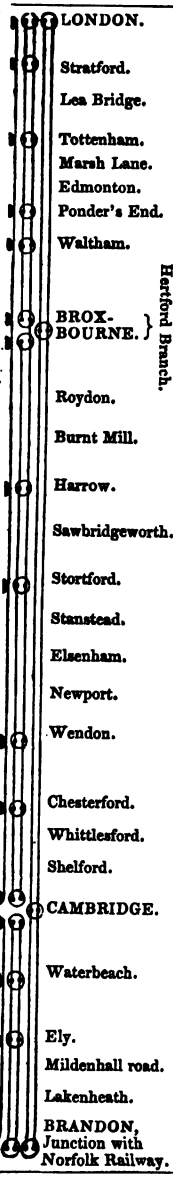

LONDON.
Stratford.
Lea Bridge.
Tottenham.
Marsh Lane.
Edmonton.
Ponder's End.
Waltham.
BROX-
BOURNE.
Hertford Branch.
Roydon.
Burnt Mill.
Harrow.
Sawbridgeworth.
Stortford.
Stanstead.
Elsenham.
Newport.
Wendon.
Chesterford.
Whittlesford.
Shelford.
CAMBRIDGE.
Waterbeach.
Ely.
Mildenhall road.
Lakenheath.
BRANDON,
Junction with
Norfolk Railway.

Fig. 15.

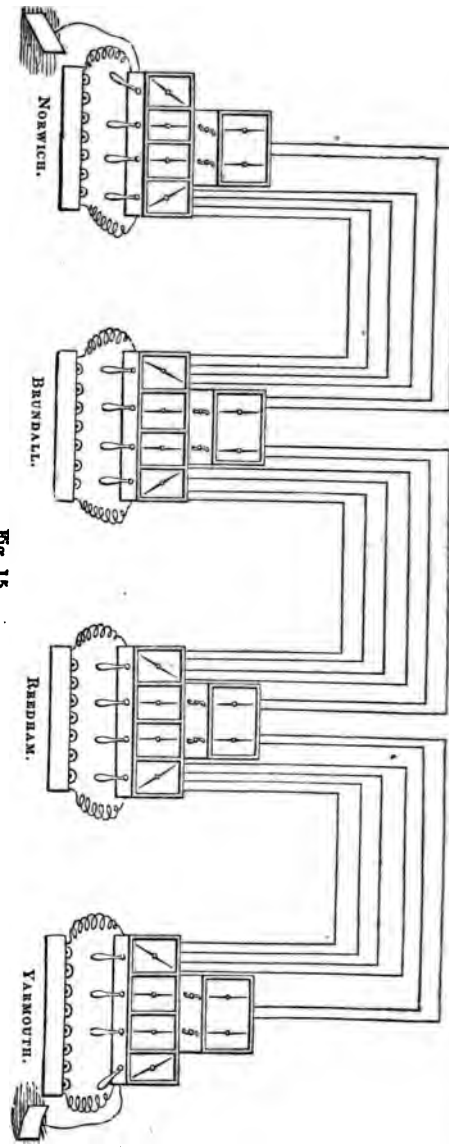

NORWICH.
BRUNDALL.
REEDHAM.
YARMOUTH.

Fig. 10.

lets, seen in fig. 11, a hammer, *h*, rapidly strikes a small bell *g*. Immediately, however, that the current ceases to flow through the coils, the iron within them loses its magnetism, a small re-acting spring, *s*, draws back the armature, and interposes the detent so as to stop the clock-work. It is necessary that the iron of the magnet should be quite pure and soft, as otherwise the magnetization is to a greater or less degree permanent; and this may be the case to such an extent as to keep the armature attracted, even after the cessation of the electric current. The bell would then continue to ring until the disengagement of the armature were caused by the hand of the attendant.

The bell or alarum may form part of the telegraphic system in two modes. In the first, and most economical, its coil is made to form part of the circuit of one of the needle wires, in conjunction with a key or rheotome. In the second and more complete method of introducing the alarum, a distinct wire is employed for it, in the course of which the magnet coils at the several stations are interposed. A key of different construction (shown in section at fig. 14) is then employed. The body is of brass, but two stout wires, z and c, are conducted through ivory tubes, and terminated in studs, *p p*, at the top and bottom of the cylindrical end of the key; the wires and studs being insulated from each other, and from the key, by the ivory in which they are fixed. The collar, *t'*, and nut, *t*, serve to secure the key to the side of the case or box in which it is placed, the former, *t'*, also containing the spring, by which, after use, the key is brought back to its quiescent position. Two springs, not shown in the figure, then rest against the metal of the end, one on each side, and while in this position, merely complete, by the intervening metal, the circuit of the bell-wire which is connected to the foot of one spring directly, and to the foot of the other by the intervention of the bell coil. The wires, z and c, are joined to the two poles of the battery by pieces of thin wire, which will offer no resistance to the revolution of the key on its axis. In the quiescent position, the course of a current entering from a distant station would be, from the line-wire on one side, along one spring, across the body of the key to the other spring, and thence through the alarum coil to the continuation of the line-wire, or to the earth connection. When, however, the bell is to be rung to call the attention of the clerk at another station, the key is for a moment turned one-quarter round. This brings the battery studs, *p p*, into the circuit, instead of the body of the key: and the current then proceeds from the battery of the ringing station by the spring and wire on one side, passes along the line, and returns by the earth through the other spring again to the battery.

The relative advantages of these two methods may be briefly stated. The first has the recommendation of economy, inasmuch as no additional wire is necessary for the bell. If, however, the clerk in charge of an instrument, after turning off his bell preparatory to sending or transmitting intelligence, should chance to leave his telegraph, and omit to turn the key so as to replace the bell in the circuit, no means are left to other stations of calling his attention, except by working the needles, with the chance of their movement meeting his eye. By the adoption of the second method, the expense of an additional wire is incurred, but the bells at all stations are constantly in a position to be rung if necessary. In addition to this, it may be remarked, that by keep-

ing the bell and needles distinct from each other, no derangement of the one is to be feared from injury to or derangement in the other.

Mr. Cooke's first plan, in the extension of the conducting wires between distant points, was, as has been already stated, to cover each wire with cotton or silk, and then with pitch, caoutchouc, resin, or other non-conducting material, and to enclose them, thus protected, in tubes or pipes of wood, iron, or earthenware. Excepting in those localities where the suspension of wires is impracticable, as in streets, towns, or on public roads, the early plan has given place to more recent inventions. In 1842, a patent was obtained by Mr. Cooke, for a means of suspending and insulating the wires in the air, and the method described in his specification has been since adhered to, with little variation. The wires are generally of iron, which is galvanized, to protect it from the action of the atmosphere. They are of about one-sixth of an inch in diameter, corresponding to No. 8 of the wire-gauge. Being obtained in as great lengths as possible, in the first place, successive pieces are welded together, until a coil of about 440 yards is formed. These rings or bundles weigh about 120 pounds each. The wires are suspended on the line, from stout squared posts or standards, of Dantzic or Memel timber. At each quarter-mile, a stronger post is fixed, from which the succeeding lengths of wire on either side are strained or tightened up. Intermediate to these principal posts, are placed smaller standards at from 45 to 55 yards asunder, for the purpose of supporting the wires. The straining apparatus is very simple, consisting merely of a reel or pulley, turning between two cheeks of cast iron, and carrying upon its axis a ratchet-wheel, into the teeth of which a click or catch falls. These winding heads, shown at *r r*, figs. 7 and 9, are connected through the post by a bolt of wrought iron *b*, tapped into each head. This bolt not only bears the strain of the wires, but also forms the metallic communication between their ends wound on the two reels. In order to insulate the bolt from the wood of the post, the hole in this latter is bored very large, and collars of eathenware, *t t*, are inserted at each side, in which the bolt rests, and against their outer surfaces the winding heads are screwed up tight. Fig. 9 is a section through the post and collar, showing this arrangement. Fig. 7 is a front, and 8 a side view of the head of a straining or quarter-post. The wires are usually arranged in two vertical planes, at the back and front of the standards, or intermediate posts. They are not strained at each quarter-mile, but at intervals of half a mile alternately; those in the front plane at one post, and those in the back plane at the next. The standards or supporting posts have merely to sustain the weight of the wires without relation to their tension. They have on each side two stout arms of oak or ash, secured by bolts, passing from one to the other, and resting in collars of earthenware, *x x*, where they pass through the standard. The wires pass through pieces of earthenware, of a double cone shape, *e e*, fastened to the outside of the arms by staples or clips, having a nut and screw at the end. These staples embrace the cones at a groove in the middle of their length. An arm similar to those on the standards is fixed to the back and front of each post alternately, to support that plane of wires which passes without being strained. The insulating earthenwares between the arm and post, *y y*, are, however, different in shape from those used

with the standard arms, as greater length is requisite. The following are the principal dimensions of the posts and poles :

LENGTH.	AT BASE.		AT TOP.	
	Posts.	Standards.	Posts.	Standards.
ft.	in. in.	in. in.	in. in.	in. in.
18	9 × 8	6 × 6	7 × 6½	5½ × 4½
22	10 × 8	7 × 6	do.	do.
28	11 × 10	8 × 7	do.	do.

For intermediate lengths the dimensions are varied proportionally. In passing through tunnels, or along the faces of walls or buildings, where posts cannot be conveniently fixed in the ground, the wires are supported on octagonal standards of oak or ash, which are fixed at about six inches from the wall by holdfasts of galvanized iron. These standards are about two inches in diameter and three feet in length, being at the top and bottom turned down to a shoulder, so as to fit into a ring at the ends of the holdfasts. The same method is adopted where the wires have to pass under bridges or archways.

The batteries employed are of a somewhat peculiar construction; they are made in the form of a Wollaston's trough, in which are arranged plates of copper and amalgamated zinc, each cell being then filled with dry and perfectly clean sand. When about to be used, the sand is just moistened with dilute sulphuric acid. These batteries are singularly constant, having been known to remain in action during a period of from two to five months, with only the occasional addition of a little more acid solution, to supply the waste by evaporation and saturation. The effect of the sand appears to be, the prevention of too rapid an action, and, at the same time, the *separation of the* sulphates of copper and zinc. No copper is therefore deposited on the zinc plate, to the destruction of this latter by local action. The only points necessary to be observed, are the perfect amalgamation of the zinc plates, the absolute freedom of the sand from lime or other alkali, from carbonates or muriates, and the purity of the sulphuric acid. The zinc is formed in rolled plates of about $\frac{1}{8}$ or $\frac{3}{16}$ of an inch in thickness, and is cut into pieces of 4½ inches by 3 inches. These plates will last with care for five or six months in almost constant action. A battery series of from 12 to 60 pairs is required, according to the length and nature of the line and the number of instruments in connection.

Six wires are extended along the whole length of railway, of which the upper pair are used with a special double-needle instrument, for verbal communication, between the main stations, which are Norwich, Brundall, Reedham, and Yarmouth. Each of the other four wires includes at every station a coil and single needle. On the dials connected with the first wire of these four, is engraved the name Norwich at all the stations; with the second, that of Brundall, with the third Reedham, and with the fourth Yarmouth. The distinct telegraphic system belonging to each station has, therefore, its representative at all the other stations. Each needle or pointer represents the state of the portion of

line under the control of the station the name of which it bears. The alarum of each instrument is connected only with the wire of its own station, so that on moving either of the needles, the alarum will be rung at the place corresponding to the name of the needle, but at no other point, although the movement of the pointer will be visible throughout.

The electric telegraph is now the chief mode of transmitting all the news of the Government, and the important correspondence of merchants and of the public generally. Its influence has been already felt by the press. The journals of the large towns, which were taken in the country on account of their giving the most recent news, have lost a great number of their subscribers; whilst there has been a very large increase in the circulation of the journals of the small towns near the extreme points of the electric telegraphs.

Renaissance, that style which arose in all the arts of design, from the introduction of antique features, consequent on the revival of classical learning, and the admiration of every thing classical after the fall of the Gothic system.

In Italy, where the arts had never become thoroughly Gothic, the system so called having been an exotic never quite naturalized in that country, the renaissance of classical principles of taste commenced as early as the 13th century; but in the rest of Europe the Gothic had then hardly arrived at its complete development, or, if become a pure and consistent system, had hardly begun to display its luxuriance; and two centuries at least were required to explore its vast capabilities, to work out its resources in all their wondrous variety, and to push on its suggestions beyond the limits of truth, and advance so far in complication and absurdity, as to render a change of style necessary; and accordingly the arts of Germany, the Netherlands, France, and England, were not ripe for this change, called the 'renaissance,' till the end of the 15th or beginning of the 16th century; *i. e.* not till after the invention of printing; the great change of society resulting from which invention, rendered the introduction of the (already renovated) classic taste into these countries a very easy and rapid transition, totally different from the slow process of renaissance and purification, by which this taste had, in Italy, gradually acquired consistency.

In architecture (the only art here alluded to) the renaissance of classical forms and principles first distinctly shows itself in the works of Brunelleschi, the great Florentine architect, who lived from 1375 to 1444. His most famous work, the cupola of the cathedral, exhibits a bold emancipation from Gothic complexity, and return to classic simplicity, without the affectation of copying classic details, which could only be abused and misapplied in a work so totally unlike in principles of construction to those of the ancients. His churches of S. Lorenzo and S. Spirito, though retaining Gothic plans and Byzanto-Gothic construction, present a still more classic treatment, not only in general design, but in that of details. The little octagonal chapel *degli Angeli* is as classic as any work of the ancient Romans, and the *Pitti* palace offers the first example of that eminently *common-sense* system of palatial architecture which continued to characterize the school of Florence throughout its career. Contemporary with this great man were Michelozzo, and L. B. Alberti, the first modern writer on the art, both of whom excelled the ancient Romans in purity of design, though the first could not give up the

Gothic window tracery, which he successively modified to his round-arched style without losing its beauty. They were succeeded by Cronaca and Bramante, the latter of whom (born the same year that Brunelleschi died) carried the revival of classicism to its perfection by re-introducing detached colonnades and hanging architraves, never attempted since the fall of ancient art, and even now (by Bramante) only on a very small scale, in the round chapel in the cloister of *S. Pietro in Monterio.* He is considered the founder of the Roman school, as Brunelleschi was of the Florentine; and his design for the modern St. Peter's, which he commenced, would have greatly excelled, in almost every kind of merit, the present jumble of twenty designs. His successor, M. Angelo, with his matchless genius for seizing whatever was grand rather than beautiful, returned (in the Capitoline Museum) to the classic simplicity of a single order, and an entablature unbroken from corner to corner: the renaissance was complete, and the modern Roman architecture having (like its sister arts) culminated in the hands of this wonderful man, or of Vignola, forthwith declined rapidly. Sanmicheli of Verona, who lived from 1484 to 1549, (a period comprised wholly in the life of M. Angelo,) originated that more fanciful and luxurious school which characterized the renaissant and modern architecture of Venice and its territory, and (being afterwards embellished by the beautiful productions of Sansovino, Palladio, and Scammozzi) became the favorite model for the schools of all transalpine countries, especially England.

In this country, a way was prepared for the introduction of classicism, by certain tendencies of our latest After-Gothic, the florid Perpendicular, and Tudor; as (I.) the tendency to subordinate the arch and archlet to the frame-work of vertical and horizontal lines; the vertical constantly increasing indeed in *number*, but the horizontal in *strength* and *importance*, probably from a feeling that the number of the one should be balanced by intensity in the other. (II.) By these horizontal masses of moulding beginning almost to approximate the effect of classic entablatures, in their division into two groups, the upper and greater answering to the cornice, the lower and smaller to the architrave, and the intermediate space being, like the frieze, either plain or sculptured, or with alternate squares of sculpture, like metopes, but never subdivided horizontally. (III.) By the roofs being reduced in pitch, (a change peculiar to the *Anglo*-Gothic decline,) and by towers being, on the same principle, finished without spires. (IV.) By the depression of the arch, the assimilation thereof to a semicircle or semi-ellipse, and the diminishing importance attached to its *point*, though that was never entirely omitted as in the French After-Gothic, called Burgundian. (V.) By the introduction of a large and bold scale of carved ornament, (as in King's College chapel, where the architecture and carving are out of all proportion to each other, a leaf being often larger than an arch or canopy, and a rose larger than a pedestal and statue together,) and by the introduction, as strikingly seen in the same building, of *attached* ornament, quite contrary to a fundamental Gothic principle, that of decorating by the *removal* of superfluous material, and not, as in classic architecture, by the *addition* of ornaments.

These several predisposing tendencies of our debased After-Gothic rendered it easy to engraft thereon those Italian details which dis-

tinguish the works of the reign of Henry VIII. The chantries of Bishops Fox and Gardiner, at Winchester, are instructive examples of this process; and so are the tomb of Henry VII., the woodwork of King's College chapel, and much of the architecture of Cambridge. At Ely is a chantry with purely Gothic vaulting, rather resembling that of the Mid-Gothic than any of the 15th century, still less of the 16th, but without bosses; and on a close inspection, rendered necessary by its dark situation, we find every rib composed of Italian cut mouldings, while the intermediate vault-surface, of plaster, is covered with the classic foliage commonly called arabesque. This shows capitally, how the Gothic (or rather After-Gothic) principles of *general design* were retained, but the *details* rendered more and more pedantic, both in our Elizabethan fashion, and in the corresponding manners of the Continent; a process just the reverse of every true advance that has taken place in architecture; for every real improvement (the arch for instance, or the pointed arch, or the buttress) has begun in main structural parts, and descended thence into details and ornaments; but the pedantry of copying classic forms, instead of classic principles, begun, except in Italy, in the smallest and least essential details, and ascended into larger and larger features; the constant aim being to hide a smaller falsehood by a greater, and thus generally rendering the whole system of building, at least in this country, more and more false, till at length, in the Anglo-Greek buildings that followed the researches of Stuart and Revett, the process of *renaissance* carried on for three centuries became complete, *i. e.* a building—no longer a collection of many little or a few great disguises—became in itself, as a whole, one immense sham.

Nor does the popular disrepute into which the perfect and unapproachable architecture of ancient Greece has now been brought by these attempts,—nor yet the romantic running after what has been (with singular ignorance) mistaken first for a 'national,' and then for a 'Christian' style,—offer any prospect of escape from the effects of this 'renaissance,' or any approach towards a true renaissance of taste; since the change is only from the mimicry of a more perfect to that of a less perfect, and (as now practised or perhaps practicable) a more limited and monotonous system: it is only from pseudo-Greek to pseudo-Gothic,—from a sham temple to a sham church. There is no hope of real renaissance till the real objects of the art be agreed upon and attended to,—till it be acknowledged that nothing is beautiful which is false, and till improvements are introduced from structural parts into ornaments,—and not, as they have been in all English architecture since its culmination in the time of the first three Edwards, from mere ornaments into the really structural parts.

THE END.

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